AD-A190 365 TUTORIAL TRACK I INTRODUCTION TO ADA(U) INFORMATION SYSTEMS AND TECHNOLOGY CENTER W-P AFB OH ADA VALIDATION FACILITY C ENGLE ET AL 09 JUN 87 1/2

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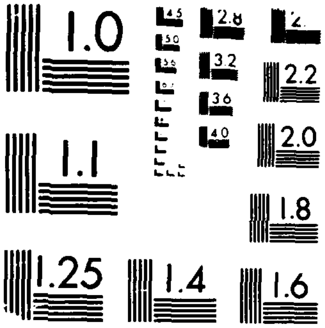

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NATIONAL BUREAU OF STANDARDS-1963-A

TUTORIAL

TRACK I

INTRODUCTION TO ADA

By

Major Charles Engle, U.S. Military Academy

and

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2

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READ INSTRUCTIONS BEFORE COMPLETING FORM

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This document contains prints of viewgraphs presented at the Introduction to Ada Tutorial, Track I June 9, 1987. Topics covered were The Software Crisis, Technical Background, Basic Constructs, Subprograms, Generics and Tasks.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

Introduction to Ada®

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OVERVIEW

I. The Software Crisis

II. Program Units

III. Types

IV. Control Statements

V. Exceptions

VI. Generics

VII. Tasks

VIII. Application Example

Types

Records

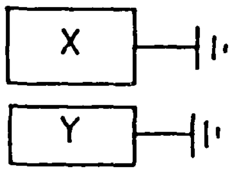
```
        A_DRIVER : INSURANCE (GOOD);
        ANOTHER : INSURANCE(BAD);

begin
     A_DRIVER.NORMAL_RATE := 25;
     A_DRIVER.DISCOUNT_RATE := 0.15;

     ANOTHER.NORMAL_RATE := 25;
     ANOTHER.ADDITIONAL := 10;
```

Types

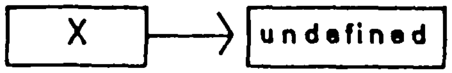
Access

-- Pointer variables
-- Allow for dynamic allocation of memory
-- Objects created via an allocator

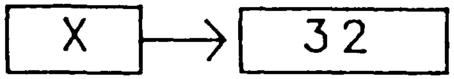
```
 type POINTER is access INTEGER;

 X, Y : POINTER;   -- initialized to
                   -- null
begin
```



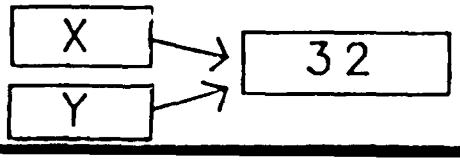
```
  X := new INTEGER; -- allocate
                    -- memory to X
```



```
  X.all := 32; -- place 32 in the
               -- location pointed to
               -- by X
```



```
  Y := X; -- X and Y point to the same
          -- location
```



Software Crisis

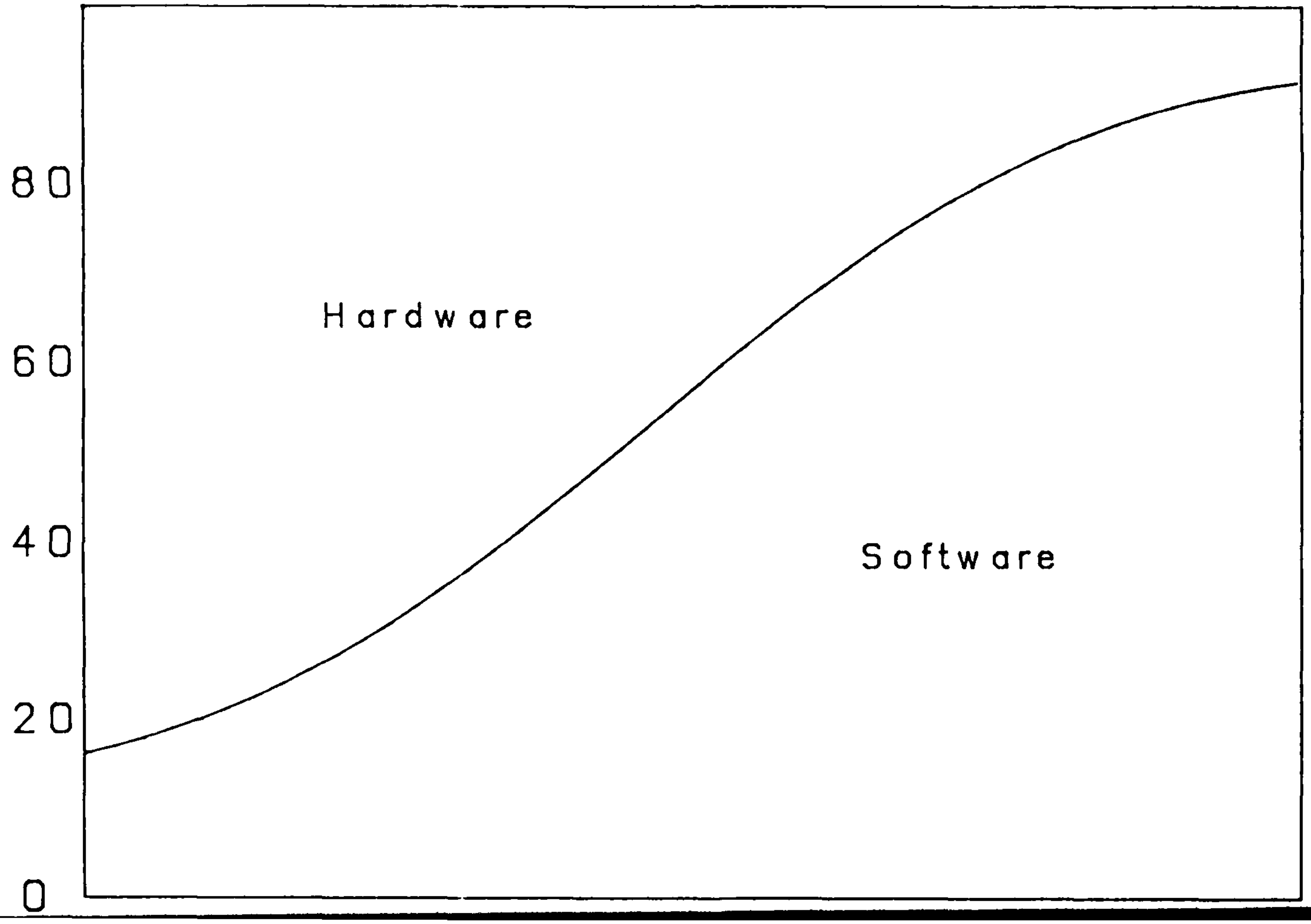
-- Rising costs of software
-- Unreliable
-- Late
-- Not maintainable
-- Inefficient
-- Not transportable

WHY??

-- Too many languages
-- Poor tools
-- Changing technology
-- Not enough trained people

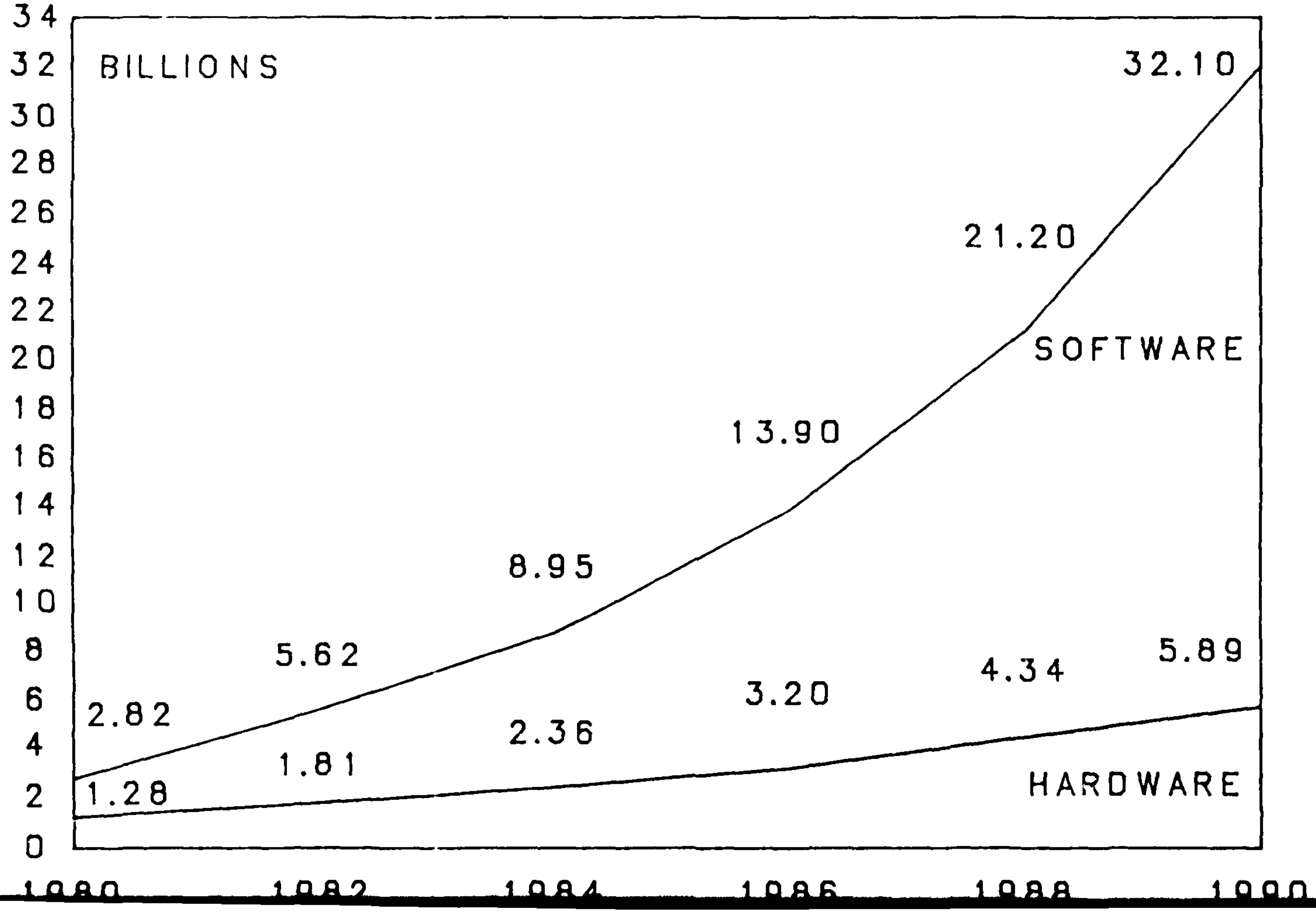
INABILITY TO MANAGE COMPLEX PROBLEMS

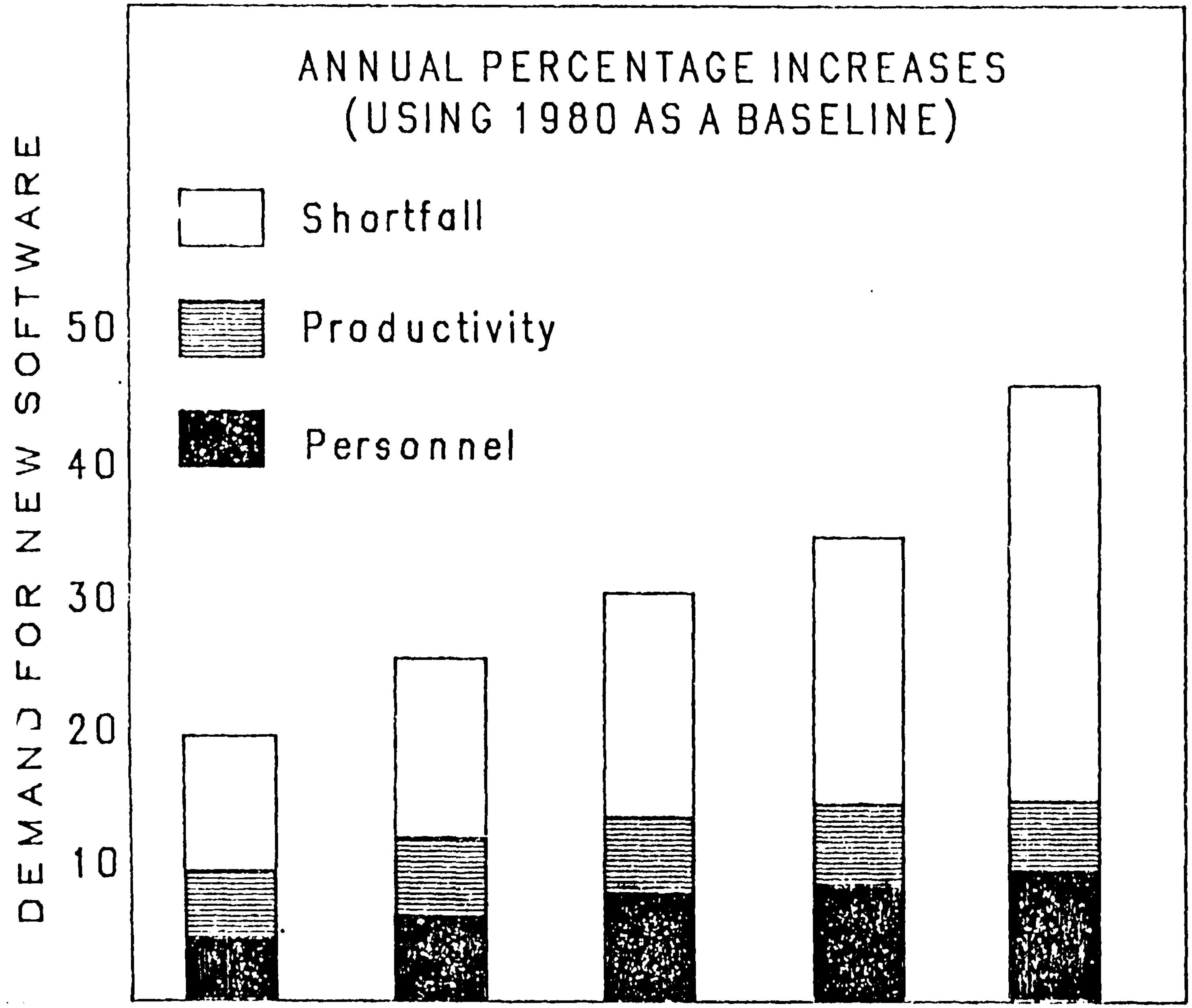
Software Crisis



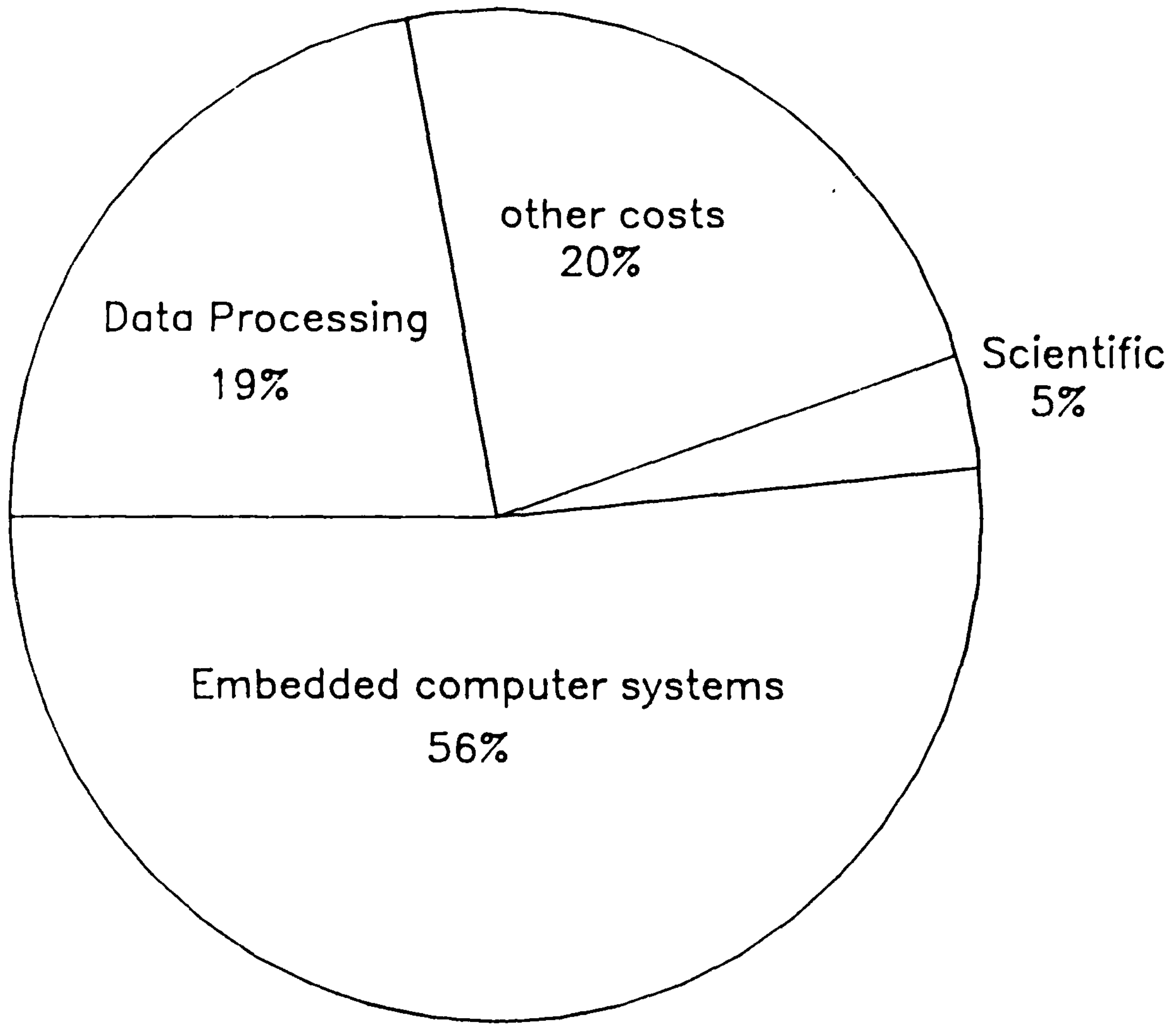
Software Crisis

DoD Embedded Hardware/Software Costs




ANNUAL PERCENTAGE INCREASES
(USING 1980 AS A BASELINE)
Shortfall
Productivity
Personnel
DEMAND FOR NEW SOFTWARE
50
40
30
20
10

Software Crisis



Software Crisis

EMBEDDED SYSTEMS

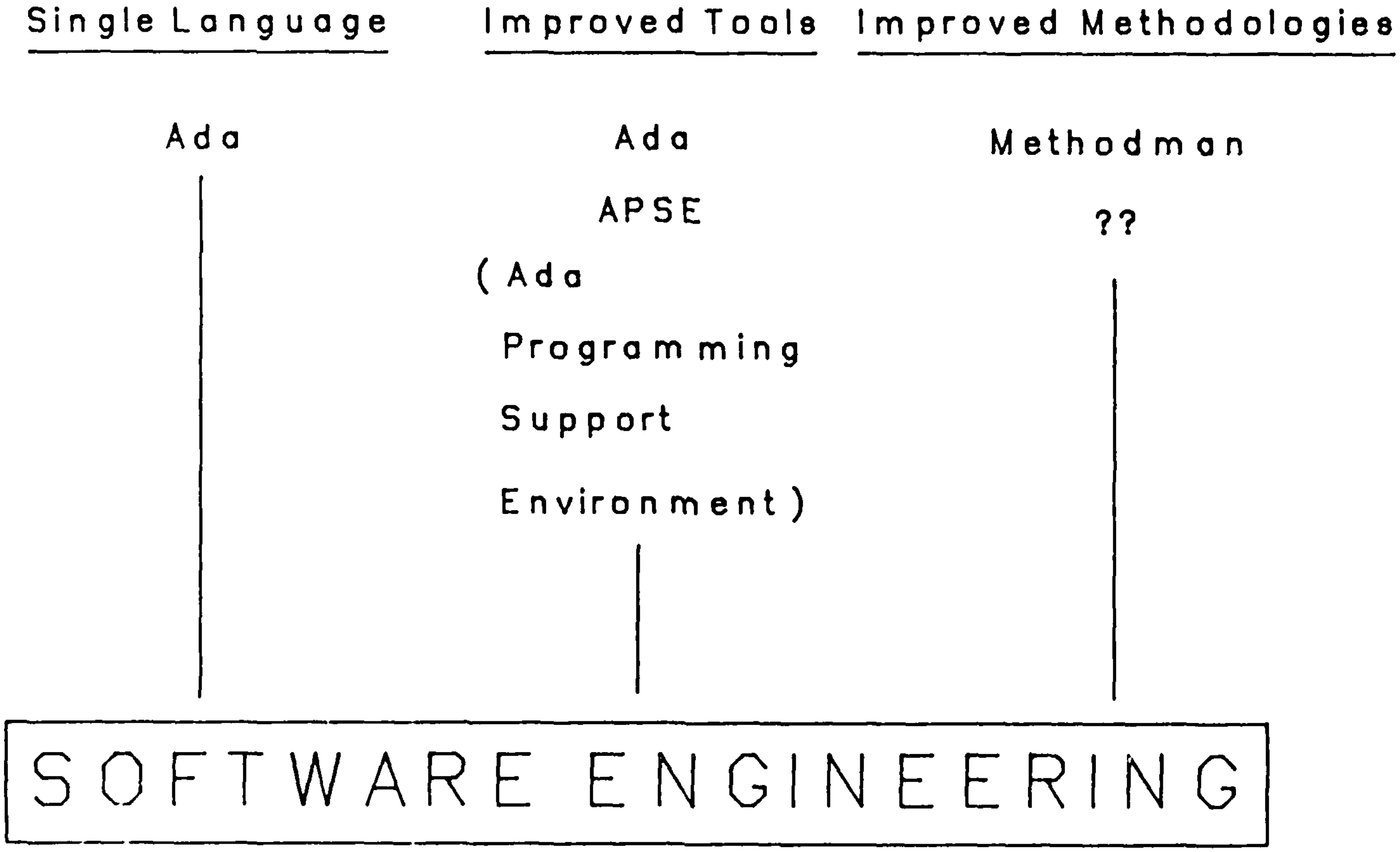
-- Large
-- Long lived
-- Continous change
-- Physical constraints
-- High reliability

EMBEDDED SYSTEMS SOFTWARE

-- Severe reliability requirements
-- Time and size constraints
-- Parallel processing
-- Real time control
-- Exception handling
-- Unique I/O

Software Crisis

SOLUTIONS



Single Language

Ada

Improved Tools

Ada

APSE

(Ada Programming Support Environment)

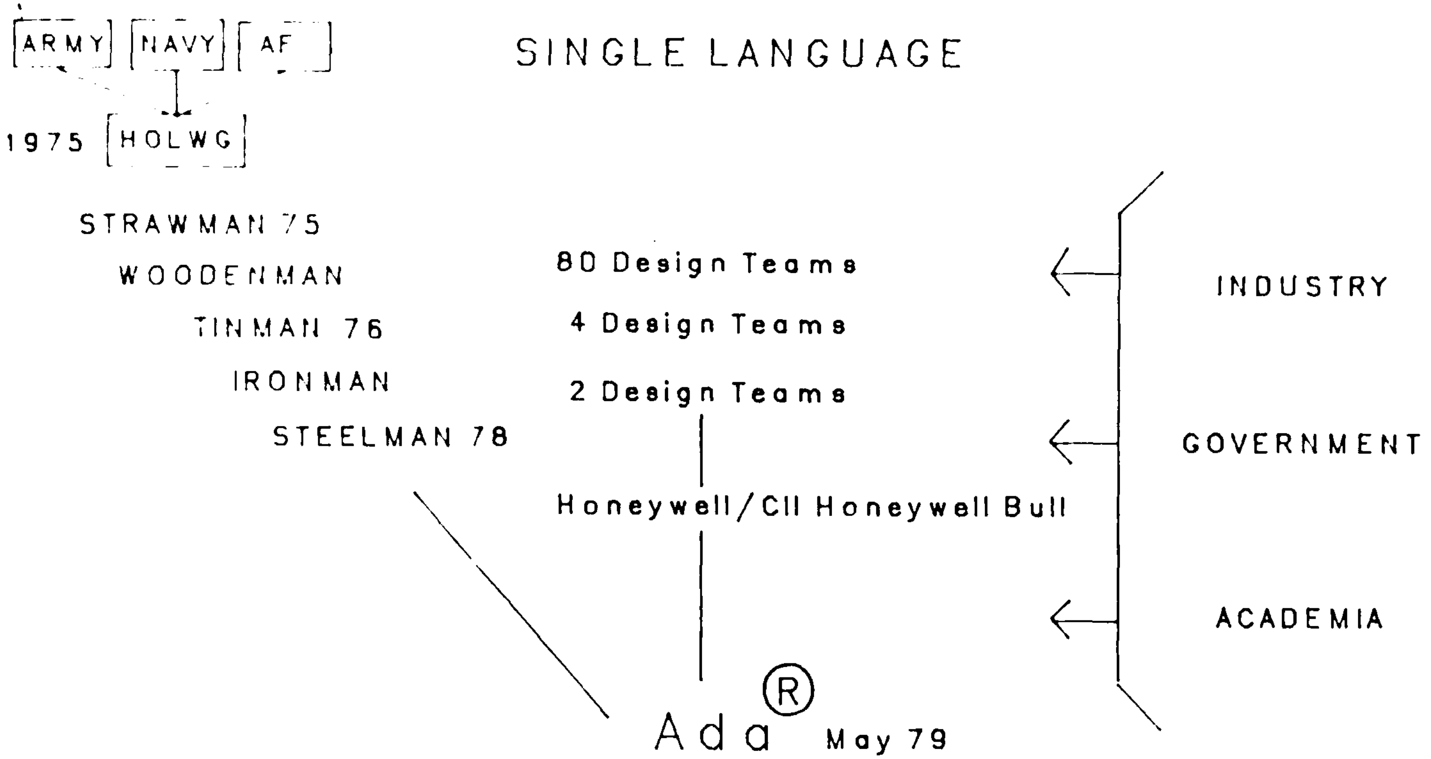
Improved Methodologies

Methodman

??

SOFTWARE ENGINEERING

Software Crisis



ARMY NAVY AF

1975 HOLWG

SINGLE LANGUAGE

STRAWMAN 75

WOODENMAN

TINMAN 76

IRONMAN

STEELMAN 78

80 Design Teams

4 Design Teams

2 Design Teams

Honeywell/CII Honeywell Bull

INDUSTRY

GOVERNMENT

ACADEMIA

Ada® May 79

Ada Joint Program Office

ANSI/MIL STD 1815A FEB 83

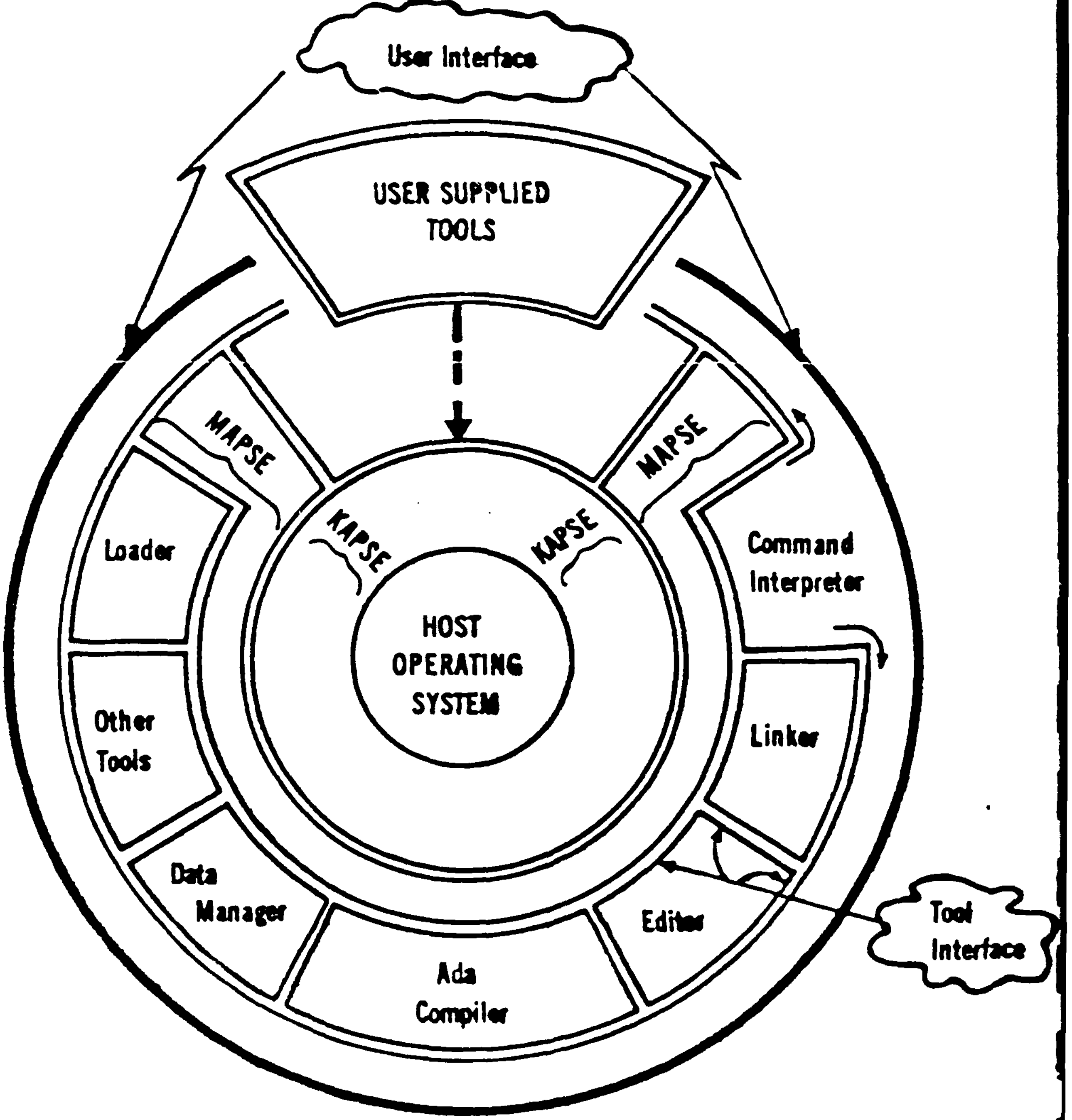
First Translator APR 83

Software Crisis

Ada Programming Support Environment

1978 SANDMAN
PEBBLEMAN
1980 STONEMAN

-- Software developer productivity
-- Retraining costs
-- Lack of tools
-- Lack of standardization


User Interface
USER SUPPLIED TOOLS
MAPSE
MAPSE
KAPSE
KAPSE
Loader
Command Interpreter
HOST OPERATING SYSTEM
Other Tools
Linker
Data Manager
Editor
Tool Interface
Ada Compiler

Software Crisis

" The basic problem is not our mismanagement of technology, but rather our inability to manage the complexity of our systems."

-- E.G. Booch

SOFTWARE ENGINEERING

GOALS

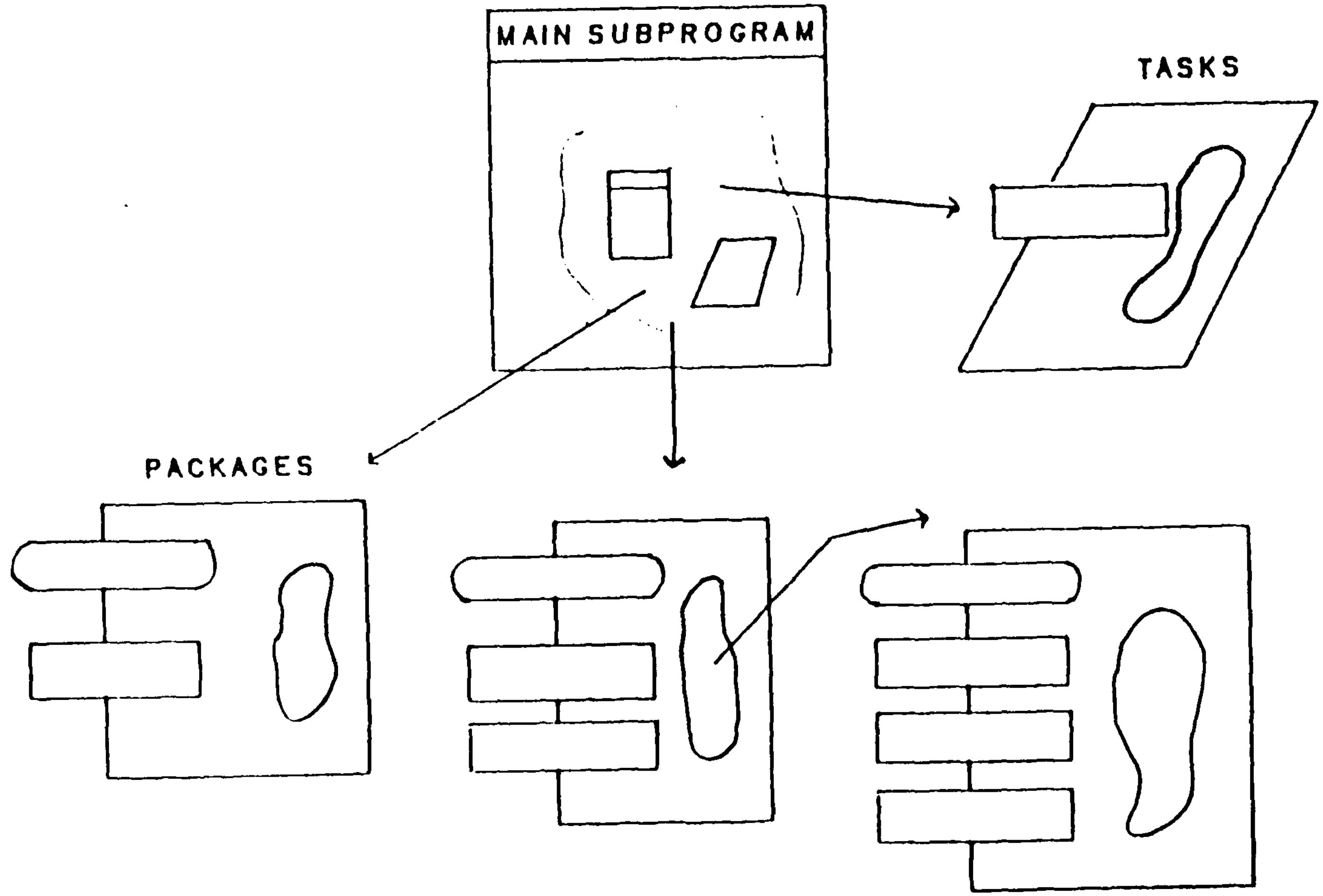
-- Understandabilty
-- Modifiability
-- Reliability
-- Efficiency

PRINCIPLES

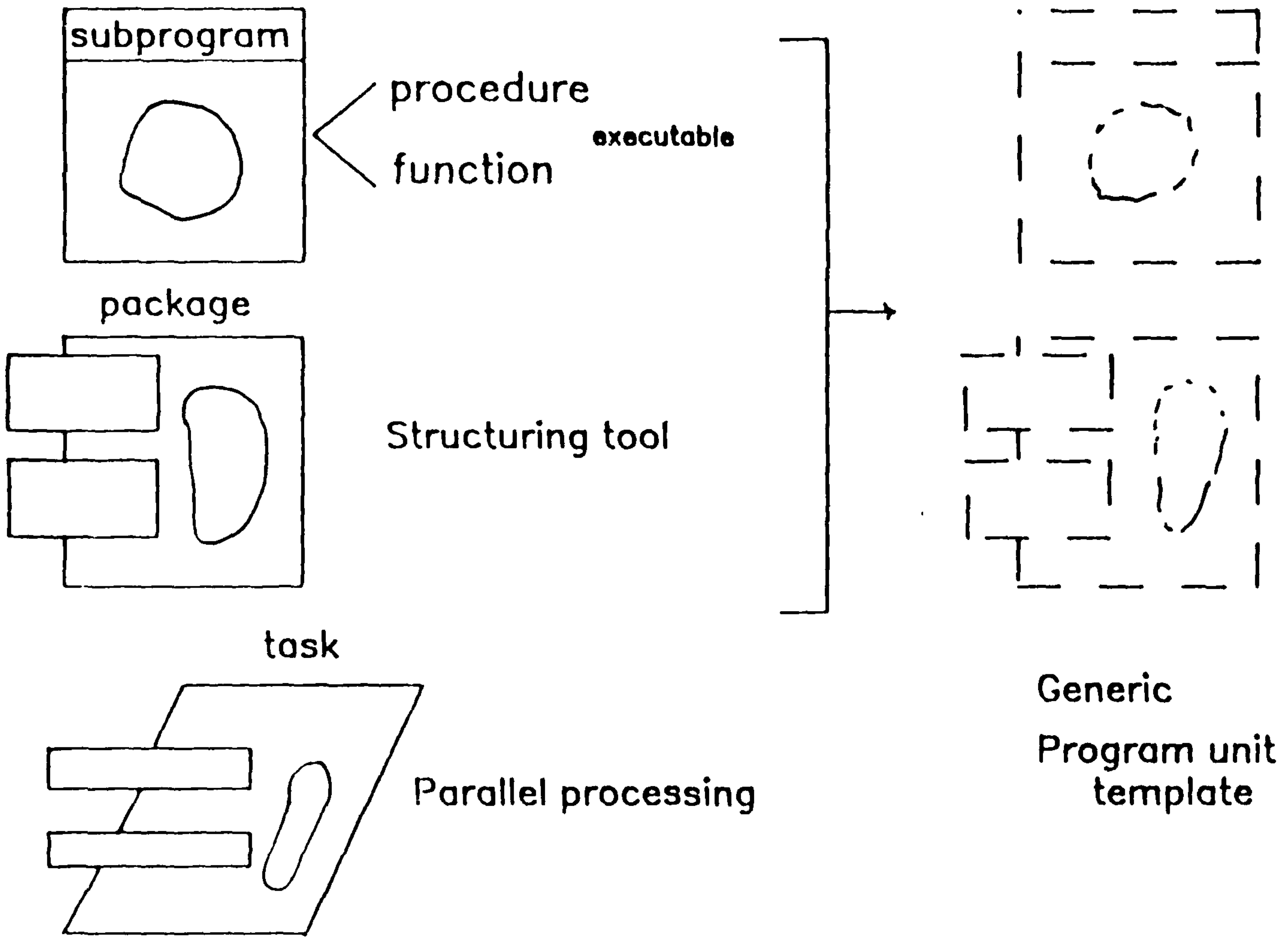
-- Abstraction
-- Information Hiding
-- Modularity
-- Localization
-- Completeness
-- Confirmabilty
-- Consistency

Program Units

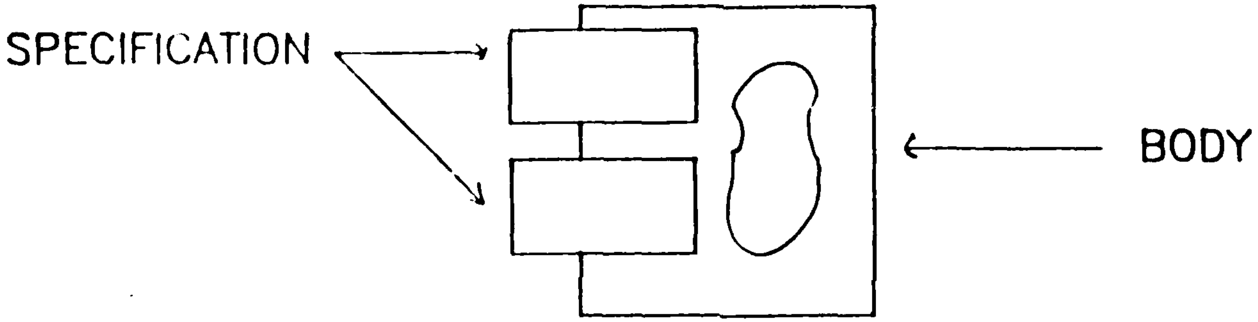
-- Ada software systems consist of one or more program units



Program Units



Program Units



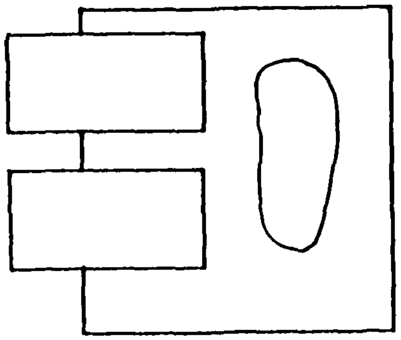
"what" the program unit does ⟸ ABSTRACTION ⟹ "how" the program unit does what it does

all the user of the program unit needs to know ⟸ INFORMATION HIDING ⟹ the details of implementation are inaccesible to the user

Program Units

By separating the "what" from the "how"...

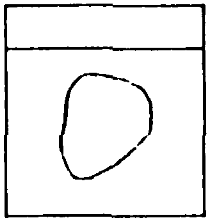
we decrease the complexity of the system...



and increase: UNDERSTANDABILITY
MODIFIABILITY

Program Units

Subprograms



-- Executable routines
-- Main program
-- Recursive

PROCEDURE
-- Defines an action to be performed

```
procedure GET_NAME ( NAME : out STRING );
                  GET_NAME ( PERSONS_NAME );
```

FUNCTION
-- Returns a value

```
function SIN ( ANGLE : in RADIANS ) return FLOAT;
           ANGLE_SIN := SIN ( 2 );
```

Program Units

Procedures

SPECIFICATION

-- Defines name
-- Defines parameters to be passed

```
procedure ADD ( FIRST : in INTEGER;
                SECOND : in INTEGER;
                RESULT : out INTEGER );
```

FIRST	:	in	INTEGER
formal parameter name		parameter mode	parameter type

Program Units

Parameter modes

in — The value passed to the subprogram acts as a constant inside and may only be read. Value remains unchanged after completion.

in out — The variable passed to the procedure may be read and updated. Value may change after completion.

out — The variable passed to the procedure may only be updated. Value may change after completion

Program Units

procedures

BODY

-- Defines the action to be performed
-- Contains a local declarative part
-- Contains a sequence of statements

```
procedure ADD ( FIRST : in INTEGER;
                SECOND : in INTEGER;
                RESULT : out INTEGER ) is
    -- local declarations go here
 begin
   RESULT := FIRST + SECOND;
 end ADD;
```

```
with ADD;
procedure SIMPLE_MATH is

    VALUE_1, VALUE_2, VALUE_3 : INTEGER := 5;

begin

    ADD ( VALUE_1, 5, VALUE_2 );
    ADD ( 10, 20, VALUE_3 );
    ADD ( VALUE_1, VALUE_2, VALUE_3 );

end SIMPLE_MATH;
```

```
with TEXT_IO;
procedure SAY_HI is

    MAX_NAME_LENGTH : constant := 80;
    subtype NAME_TYPE is STRING(1..MAX_NAME_LENGTH);

    YOUR_NAME : NAME_TYPE := (others => ' ' );

    NAME_LENGTH : NATURAL := 0;

begin

    TEXT_IO.PUT_LINE("What is your name? ");
    TEXT_IO.GET_LINE( YOUR_NAME, NAME_LENGTH );
    TEXT_IO.PUT( "Hi ");
    TEXT_IO.PUT_LINE( YOUR_NAME(1..NAME_LENGTH) );
    TEXT_IO.PUT_LINE( "Have a nice day!!");

end SAY_HI;
```

Program Units

```
procedure AN_EXAMPLE is
     MY_INTEGER : INTEGER := 10;
     TEMP       : INTEGER :=  0;

     procedure NEXT (AN_INTEGER : in   INTEGER;
                     VALUE      :out INTEGER) is
      begin
          VALUE := AN_INTEGER + 1;
      end NEXT;
begin
     while MY_INTEGER <= 100 loop
          NEXT(MY_INTEGER,TEMP);
          MY_INTEGER := TEMP;
      end loop;
end AN_EXAMPLE;
```

Program Units

Functions

SPECIFICATION

-- Defines name
-- Defines parameters to be passed
-- Defines result type

```
function ADD ( FIRST, SECOND : in INTEGER )
                              return INTEGER;
```

-- parameter mode can only be "in"
-- called as an expression

Program Units

Functions

BODY

-- Defines the action to be performed
-- Contains a declarative part
-- Contains a sequence of statements
-- Result returned in a "return" statement

```
function ADD ( FIRST, SECOND : INTEGER )
                              return INTEGER is
begin
   return FIRST + SECOND;
end ADD;
```

Program Units

Functions

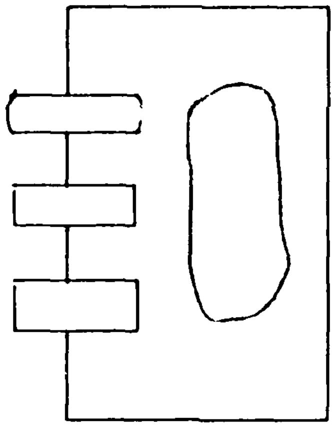
```
procedure CALCULATIONS is
   VALUE : INTEGER := 1;
   function ADD_PREVIOUS ( NUMBER : in INTEGER )
                                       return INTEGER is
   begin
     return NUMBER + ( NUMBER – 1 );
   end ADD PREVIOUS;

begin

   VALUE := ADD_PREVIOUS ( 5 );
   -- value equals 9

end CALCULATIONS;
```

```
procedure ADD_THEM is

   type INDEX_TYPE is range 1 .. 3;
   type REAL is digits 9;
   type MATRIX_TYPE is array(INDEX_TYPE, INDEX_TYPE)
                                             of REAL;


   function "+" (LEFT, RIGHT : in MATRIX_TYPE)
                      return MATRIX_TYPE is separate;

   FIRST, SECOND,
   RESULT : MATRIX_TYPE := (others => 0.0);

begin

   RESULT := FIRST + SECOND;

end ADD_THEM;
```

```
separate ( ADD_THEM )
function "+" ( LEFT, RIGHT : in MATRIX_TYPE) return
                                         MATRIX_TYPE is
   TEMP_MATRIX : MATRIX_TYPE := ( others => 0.0 );

begin

  for FIRST_INDEX in MATRIX_TYPE'RANGE(1) loop

     for SECOND_INDEX in MATRIX_TYPE'RANGE(2) loop


        TEMP_MATRIX(FIRST_INDEX, SECOND_INDEX ) :=
           LEFT(FIRST_INDEX,SECOND_INDEX) +
           RIGHT(FIRST_INDEX,SECOND_INDEX);

     end loop;
  end loop;
  return TEMP_MATRIX;

end "+";
```

Program Units

Packages



-- Defines groups of logically related items
-- Structuring tool
-- Contains a visible part (specification)
   and a hidden part (private part and body)
-- Primary means for extending the language

Program Units

Package specification

```
-- Define items available to user of package ( export )

package CONSTANTS is
   PI : constant := 3.14159;
   e : constant := 2.71828;
   WARP : constant := 3.00E+08;
                            -- meters/second
end CONSTANTS;
```

```
with CONSTANTS;
procedure SOME_PROGRAM is

   MY_VALUE : FLOAT := 2 * CONSTANTS.PI;

begin
   null;
end SOME_PROGRAM;


with CONSTANTS;
procedure ANOTHER_PROGRAM is

   ANOTHER_VALUE : FLOAT := 2 * CONSTANTS.PI;

begin
   null;
end ANOTHER_PROGRAM;
```

Program Units

```
package ROBOT_CONTROL is

   type SPEED is range 0..100;
   type DISTANCE is range 0..500;
   type DEGREES is range 0..359;
   procedure GO_FORWARD ( HOW_FAST : in SPEED;
                          HOW_FAR : in DISTANCE );
   procedure REVERSE ( HOW_FAST : in SPEED;
                       HOW_FAR : in DISTANCE );
   procedure TURN ( HOW_MUCH : in DEGREES );

end ROBOT_CONTROL;
```

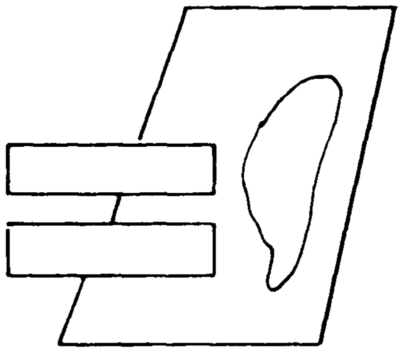
```
with ROBOT_CONTROL;

procedure DO_A_SQUARE is
begin

    ROBOT_CONTROL.GO_FORWARD( HOW_FAST => 100,
                              HOW_FAR => 20 );
    ROBOT_CONTROL.TURN( 90 );
    ROBOT_CONTROL.GO_FORWARD( 100, 20 );
    ROBOT_CONTROL.TURN( 90 );
    ROBOT_CONTROL.GO_FORWARD( 100, 20 );
    ROBOT_CONTROL.TURN( 90 );
    ROBOT_CONTROL.GO_FORWARD( 100, 20 );
    ROBOT_CONTROL.TURN ( 90 );

end DO_A_SQUARE;
```

Program Units

Package bodies

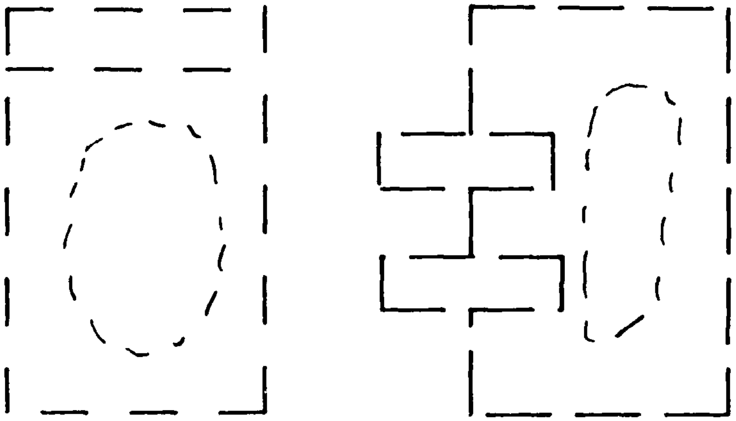
```
--Define local declarations
--Define implementation of subprograms
-- defined in specification
package body ROBOT_CONTROL is
    --local declarations
    procedure RESET_SYSTEM is
    begin
        --implementation
    end RESET_SYSTEM;
    procedure GO_FORWARD...is...
    procedure REVERSE...is...
    procedure TURN...is...
end ROBOT_CONTROL;
```

Program Units



TASK

A program unit that operates in parallel with other program units



GENERIC

Template of a subprogram or package

Types

--A type consists of a set of values that objects of the type may take on, and a set of operations applicable to those values

--Ada is a strongly typed language!

*Every object must be declared of some type name
*Different type names may not be implicitly mixed
*Operations on a type must preserve the type

```
AN_INTEGER      : INTEGER;
A_FLOAT_NUMBER : FLOAT ;
ANOTHER_FLOAT   : FLOAT;

A_FLOAT_NUMBER := ANOTHER_FLOAT + AN_INTEGER;
                  --illegal
```

Types

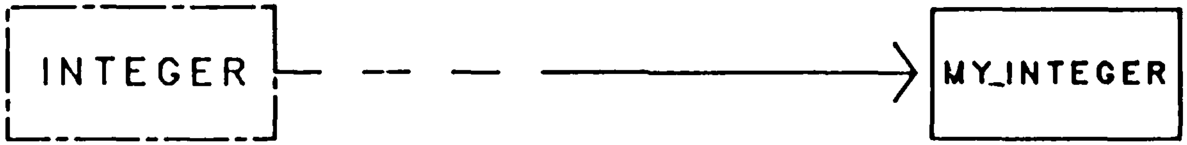
Types and Objects

TYPES

Define a template for objects

OBJECTS

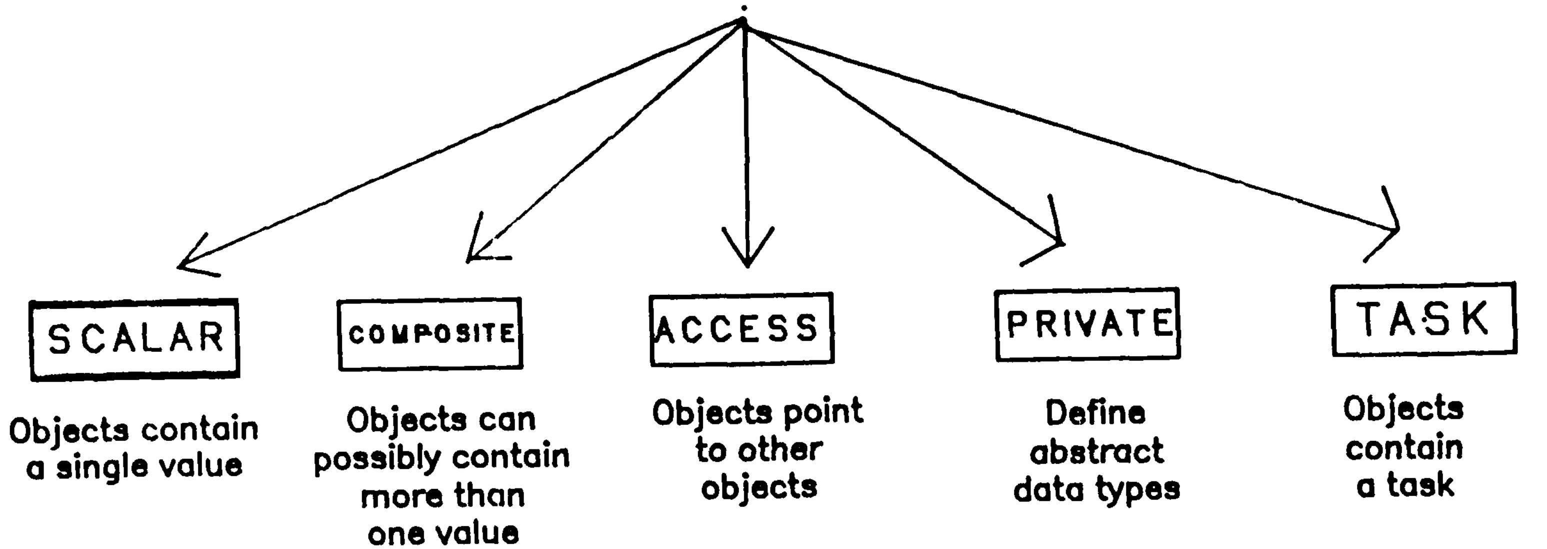
Variables or constants that are instances of a type



OBJECT DECLARATION

```
MY_INTEGER : INTEGER;
YOUR_INTEGER : INTEGER := 10;
```

Ada Types



SCALAR

Objects contain a single value

COMPOSITE

Objects can possibly contain more than one value

ACCESS

Objects point to other objects

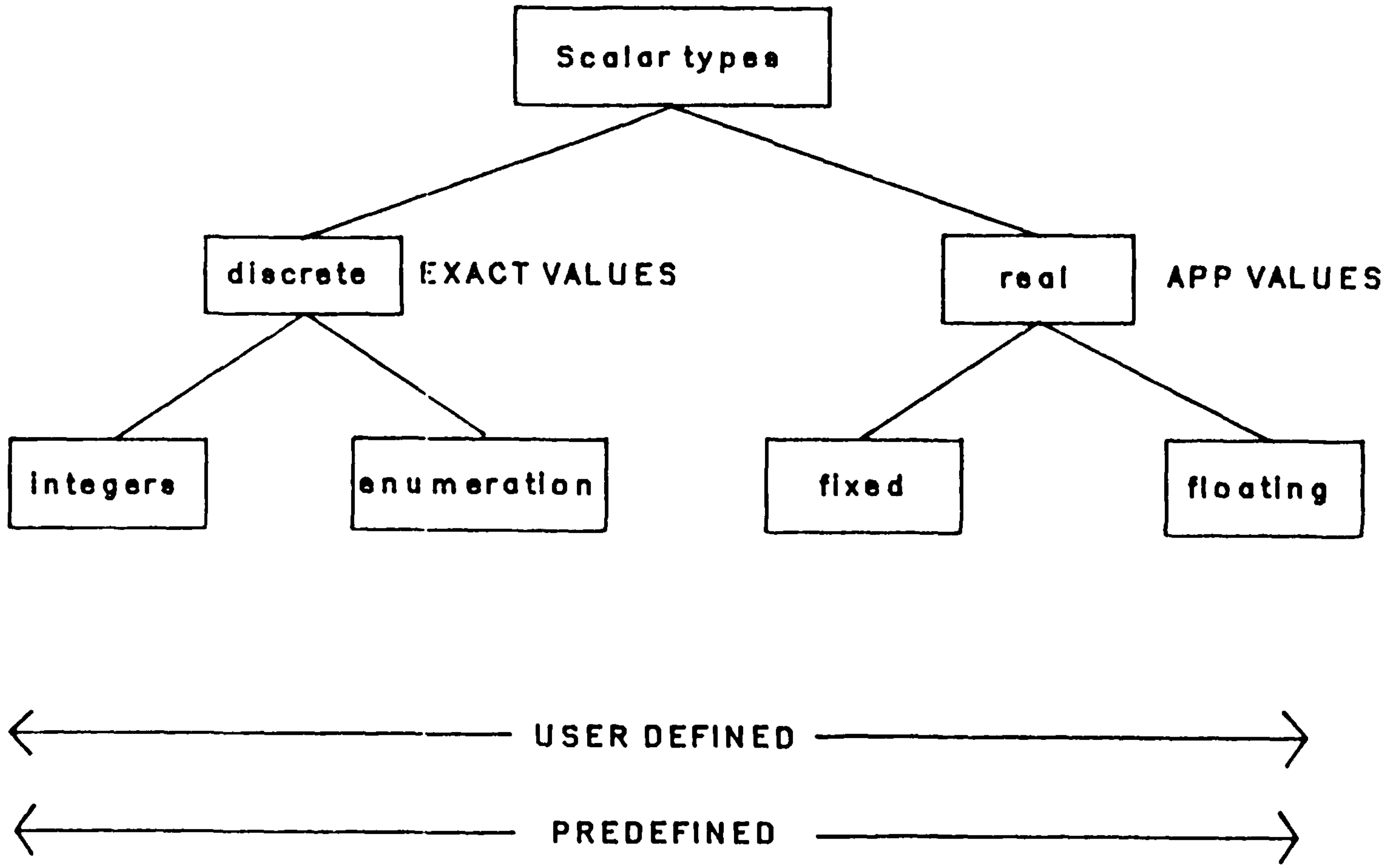
PRIVATE

Define abstract data types

TASK

Objects contain a task

Types


Scalar types
discrete
EXACT VALUES
real
APP VALUES
integers
enumeration
fixed
floating
USER DEFINED
PREDEFINED

Types

Integers

--Define a set of exact, consecutive values

USER DEFINED

```
        type ALTITUDE is range 0..100_000;
        type DEPTH is range 0..20_000;
        PLANES_HEIGHT : ALTITUDE;
        DIVER_DEPTH : DEPTH;

 begin
    PLANES_HEIGHT := 10_000;
    PLANES_HEIGHT := 200_000;  -- error
    PLANES_HEIGHT := DIVER_DEPTH; -- error
 end;
```

Types

Predefined integer types

INTEGER----------------->(usually −32,768..32767)

"subtypes" of INTEGER

NATURAL(0..INTEGER'LAST)

POSITIVE(1..INTEGER'LAST)

LONG_INTEGER----------------->(usually double word)

SHORT_INTEGER----------------->(usually half word)

Types

Subtypes

-- Constrain a range of values or accuracy on a type
-- Does not define a new type ,i.e., compatible
with base type

```
type ALTITUDE is range 0..200_000;
subtype HIGH is ALTITUDE range 40_000 .. 200_000;
subtype MEDIUM is ALTITUDE range 10_000 .. 100_000;
subtype LOW is ALTITUDE range 0 .. 10_000;
```

Types

Enumeration

--Define a set of ordered enumeration values
--Used in array indexing, case statements,
--   and looping

USER DEFINED

```
type SUIT is (CLUBS, HEARTS, DIAMONDS, SPADES);
type COLOR is (RED, WHITE, BLUE);
type SWITCH is (OFF, ON);
type EVEN DIGITS is ('2','4','6','8');
type MIXED is (ONE,'2',THREE,'*','!',more);
```

where CLUBS < HEARTS < DIAMONDS < SPADES
(pos 0)   (pos 1)   (pos 2)   (pos 3)

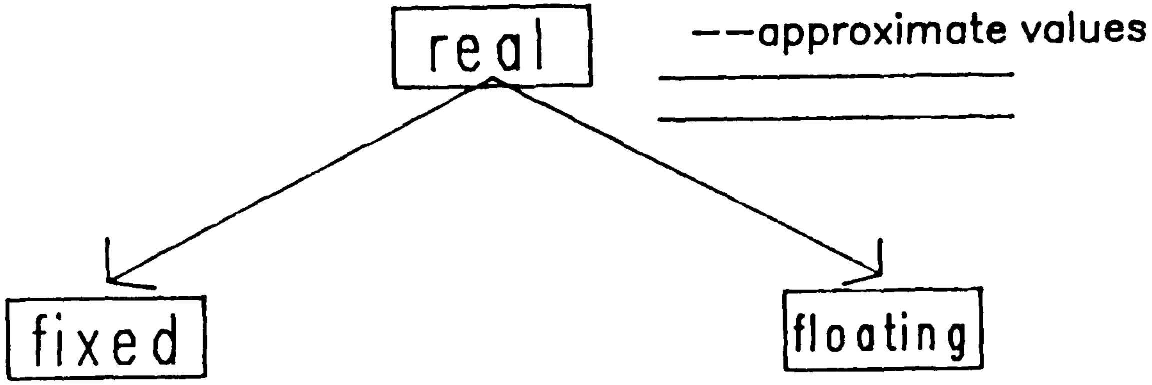
Types

Pre–defined enumeration types

BOOLEAN ---------------------> (FALSE, TRUE)

CHARACTER

Types



real

--approximate values

fixed

floating

fixed point arithmetic

floating point arithmetic

Types

Fixed point types

-- Absolute bound on error
-- Larger error for smaller numbers (around zero)

USER DEFINED

```
   type INCREMENT is delta 1.0/8 range 0.0 .. 1.0;

  0,  1*2e-3,  2*2e-3,  4*2e-3,  5*2e-3,...
```

PREDEFINED

  DURATION --> (Used for "delay" statements)

Types

Floating point types

-- Relative bound of error
-- Defined in terms of significant digits
-- More accurate at smaller numbers, less at larger

USER DEFINED

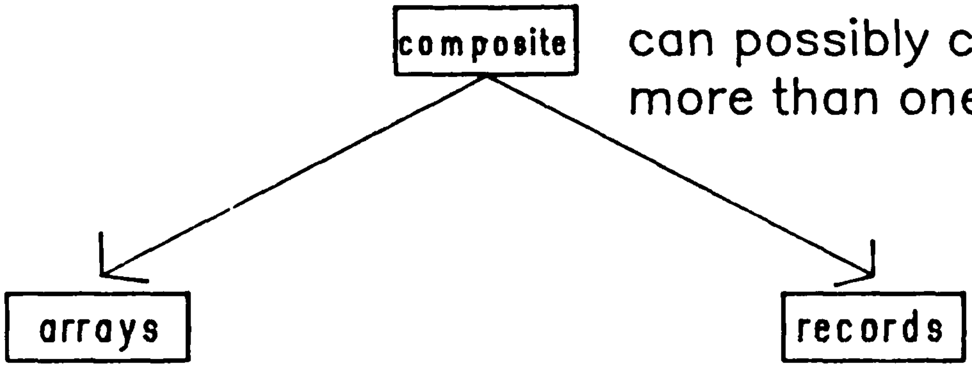
```
type NUMBERS is digits 3 range 0.0 .. 20_000;
```

$$0.\underline{001},\ 0.\underline{002},\ 0.\underline{003}\ldots\underline{999}.0,\underline{100}0.0,\underline{100}1.0\ldots,\underline{100}00.0,\underline{101}00.0$$

PREDEFINED

FLOAT

Types



can possibly contain
more than one value

components are all
of the same type
(homogeneous)

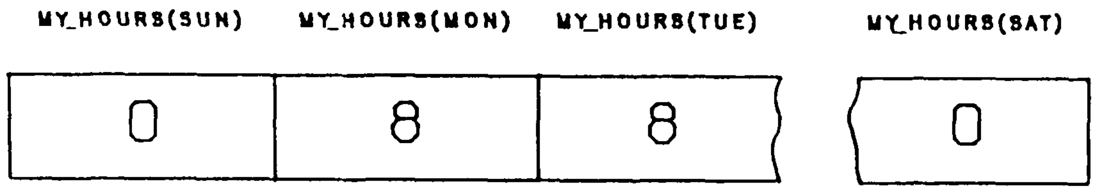
components are of
potentially different types
(heterogeneous)

Types

Arrays — constrained / unconstrained

CONSTRAINED

```
-- Indices are static for all objects of that type

type HOURS is range 0..40;
type DAYS is ( SUN,MON,TUE,WED,THU,FRI,SAT );
type WORK_HOURS is array( DAYS ) of HOURS;

MY_HOURS : WORK_HOURS := ( 0,8,8,7,6,1,0 );
```



Types

Arrays

UNCONSTRAINED

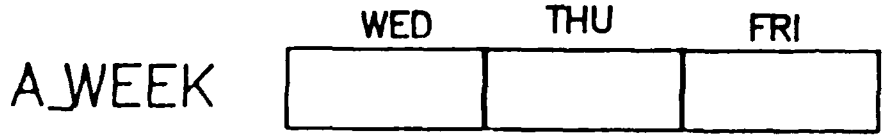
--Indices are known at elaboration (run) time

--Indices may be different for different objects

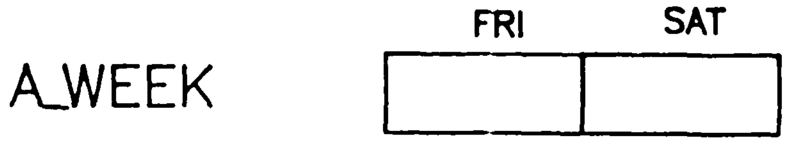
```
type HOURS is range 0..40;
type DAYS is (SUN,MON,TUE,WED,THU,FRI,SAT);
type WORK_HOURS is array (DAYS range <>) of HOURS;

HOLIDAY_WEEK : WORK_HOURS (TUE..SAT) :=(others =>0);
FULL_WEEK : WORK_HOURS (DAYS'FIRST..DAYS'LAST);
```

Types

```
procedure DAYS_WORKED (FIRST,SECOND: in DAYS) is

     A_WEEK : WORK_HOURS (FIRST..SECOND);

  begin
    .
    .
    .
    .
  DAYS_WORKED(WED,FRI);
```



```
  DAYS_WORKED(FRI,SAT);
```



Types

Multi–dimensional arrays

```
  type VALUES is digits 6 range –10.0 .. 100.0;
  type INDEX is range 1..3;
  type TWO_D_MATRIX is array (INDEX,INDEX) of VALUES;

  MY_MATRIX : TWO_D_MATRIX := ( others => 0.0 );
  IDENTITY_MATRIX : constant TWO_D_MATRIX := ( (1.0,0.0,0.0),
                                               (0.0,1.0,0.0),
                                               (0.0,0.0,1.0));

begin

  MY_MATRIX := IDENTITY_MATRIX;
  MY_MATRIX (3,3) := 2.0;
  .
  .
  .
```

Types

Array

PREDEFINED

```
type STRING is array (POSITIVE range <>) of CHARACTER;
```

USE OF THE PREDEFINED STRING TYPE

```
YOUR_STRING : STRING (1..10);
MY_STRING : STRING (1..20);
THEIR_STRING : STRING; -- illegal
```

STRING SLICING

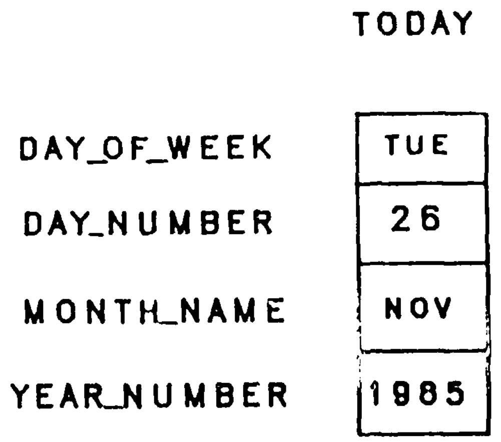
```
YOUR_STRING := MY_STRING(1..10);
MY_STRING(11..15) := YOUR_STRING(2..6);
MY_STRING(3..4) := MY_STRING(4..5);
MY_STRING(2) := 'G';
MY_STRING(2) := "G";  -- illegal
```

Types

Records

undiscriminated
discriminated
variant

```
UNDISCRIMINATED
   type DAYS is ( MON,TUE,WED,THU,FRI,SAT,SUN );
   type DAY is range 1..31;
   type MONTH is (JAN,FEB,MAR,APR,MAY,JUN,JUL,AUG,
                         SEP,OCT,NOV,DEC);
   type YEAR is range 0..2085;
   type DATE is record
      DAY_OF_WEEK : DAYS;
      DAY_NUMBER : DAY;
      MONTH_NAME : MONTH;
      YEAR_NUMBER : YEAR;
   end record;
   TODAY : DATE;
begin
   TODAY.DAY_OF_WEEK := TUE;
   TODAY.DAY_NUMBER := 26;
   TODAY.MONTH_NAME := NOV;
```



Types

Records

```
    type A_MONTH is array (DAY range <>) of DATE;
    NOVEMBER: A_MONTH(1..30);

begin

    NOVEMBER(26).DAY_OF_WEEK := TUE;
    NOVEMBER(27) := (WED,27,NOV,1985);
```

Types

Records

DISCRIMINATED

```
      type BUFFER(SIZE:POSITIVE := 10) is record
         ITEMS : STRING(1..SIZE);
      end record;

      MY_BUFFER : BUFFER; -- size is 10;
      YOUR_BUFFER : BUFFER (20);
      THEIR_BUFFER : BUFFER (SIZE => 15);

  begin
       MY_BUFFER.ITEMS := "Hi There!!";
```

Types

Records

VARIANT

```
type DRIVER is (GOOD,BAD);
type INSURANCE_RATE is range 1..50;
type DISCOUNT is delta 0.01 range 0.0..1.0;
type INSURANCE (KIND:DRIVER) is record
   NORMAL_RATE : INSURANCE_RATE;
   case KIND is
         when GOOD => DISCOUNT_RATE : DISCOUNT ;
         when BAD => ADDITIONAL : INSURANCE_RATE;
    end case;
 end record;
```

Types

Records

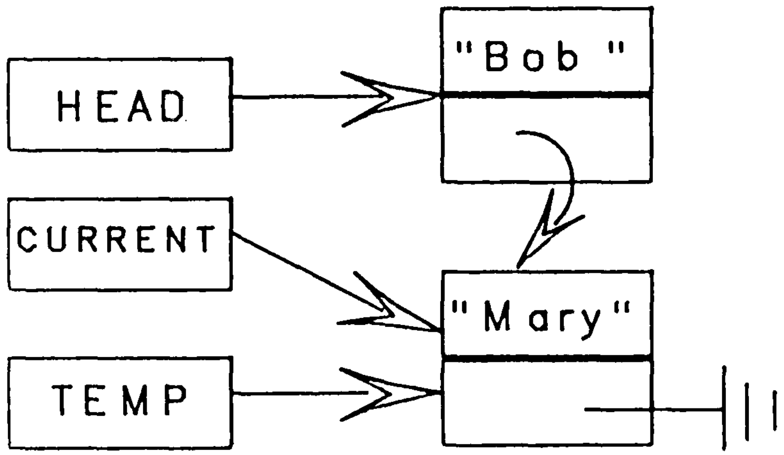
VARIANT

```
type DRIVER is (GOOD,BAD);
type INSURANCE_RATE is range 1..50;
type DISCOUNT is delta 0.01 range 0.0..1.0;
type INSURANCE (KIND:DRIVER) is record
   NORMAL_RATE : INSURANCE_RATE;
   case KIND is
         when GOOD => DISCOUNT_RATE : DISCOUNT ;
         when BAD => ADDITIONAL : INSURANCE_RATE;
    end case;
 end record;
```

Types

Access types— Linked list

```
--Move current pointer
CURRENT := TEMP;
```

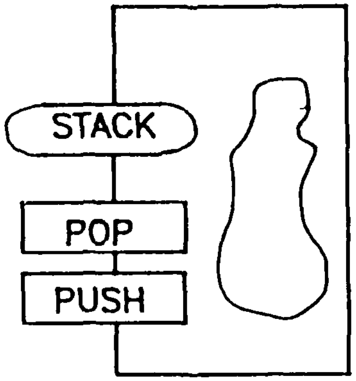


Types

Private types

-- Defined in a package
-- Used to create abstract data types
-- Used to extend the language
-- Directly supports abstraction and
-- Information hiding

INTEGER_STACK



PRIVATE

:= = /=
subprograms defined in
package specification

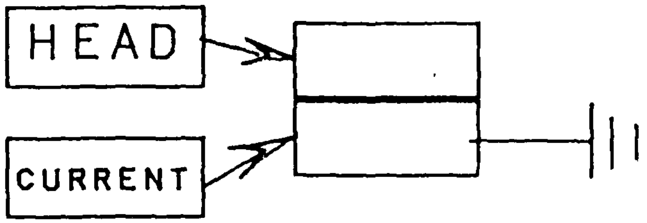
LIMITED PRIVATE

only subprograms
defined in
package specification

Types

Access types – Linked list

```
procedure LINKED LIST is
  type ITEM;  – incomplete type declaration
  type POINTER is access ITEM;
  type ITEM is record
        NAME: STRING(1..20):=(others =>' ');
        NEXT : POINTER;
   end record;

   HEAD,CURRENT,TEMP:POINTER; ––initialized to null

begin

   HEAD:=new ITEM;
   CURRENT:=HEAD;
```



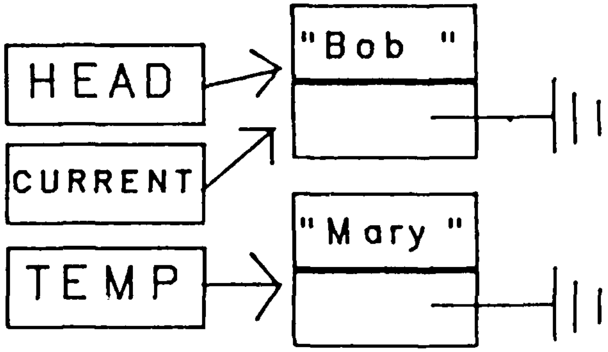
```
   CURRENT.NAME(1..3):= "Bob";
```

Types

Access types – Linked list

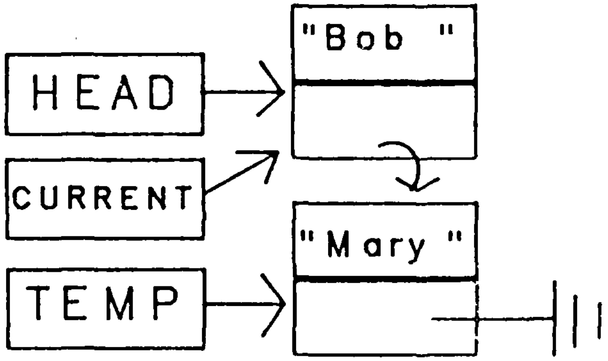
Create a New Item

```
TEMP := new ITEM;
TEMP.NAME(1..4):="MARY ";
```



Add to List

```
CURRENT.NEXT:=TEMP;
```



```
package BASKIN_ROBBINS is

   type NUMBERS is range 0 .. 99;

   procedure TAKE( A_NUMBER : out NUMBERS );

   procedure NOW_SERVING return NUMBERS;

   procedure SERVE( A_NUMBER : in NUMBERS );

end BASKIN_ROBBINS;
```

```
with BASKIN_ROBBINS;
procedure GET_ICE_CREAM is

  YOUR_NUMBER : BASKIN_ROBBINS.NUMBERS;

begin

  BASKIN_ROBBINS.TAKE( YOUR_NUMBER );
  loop

     if BASKIN_ROBBINS."="( BASKIN_ROBBINS.NOW_SERVING,
                            YOUR_NUMBER );

        BASKIN_ROBBINS.SERVE( YOUR_NUMBER );

        exit;

     end if;
  end loop;


end GET_ICE_CREAM;
```

```
with BASKIN_ROBBINS; use BASKIN_ROBBINS;
procedure GET_ICE_CREAM is

   YOUR_NUMBER : BASKIN_ROBBINS.NUMBERS;

begin

   BASKIN_ROBBINS.TAKE( YOUR_NUMBER );
   loop

      if BASKIN_ROBBINS.NOW_SERVING = YOUR_NUMBER then
          BASKIN_ROBBINS.SERVE( YOUR_NUMBER );
          exit;
      else

          YOUR_NUMBER := YOUR_NUMBER - 1;

      end if;

   end loop;

end GET_ICE_CREAM;
```

```
package BASKIN_ROBBINS is

   type NUMBERS is private;

   procedure TAKE( A_NUMBER : out NUMBERS );

   procedure NOW_SERVING return NUMBERS;

   procedure SERVE( A_NUMBER : in NUMBERS );

private

   type NUMBERS is range 0 .. 99;

end BASKIN_ROBBINS;
```

```
with BASKIN_ROBBINS; use BASKIN_ROBBINS;
procedure GET_ICE_CREAM is

   YOUR_NUMBER : BASKIN_ROBBINS.NUMBERS;

begin

   BASKIN_ROBBINS.TAKE( YOUR_NUMBER );
   loop

      if BASKIN_ROBBINS.NOW_SERVING = YOUR_NUMBER then
         BASKIN_ROBBINS.SERVE( YOUR_NUMBER );
         exit;
      else

         YOUR_NUMBER := BASKIN_ROBBINS.NOW_SERVING;

      end if;

   end loop;

end GET_ICE_CREAM;
```

```
package BASKIN_ROBBINS is

   type NUMBERS is limited private;

   procedure TAKE( A_NUMBER : out NUMBERS );

   procedure NOW_SERVING return NUMBERS;

   procedure SERVE( A_NUMBER : in NUMBERS );

   function "="( LEFT, RIGHT : NUMBERS) return BOOLEAN;


private
   type NUMBERS is range 0 .. 99;
end BASKIN_ROBBINS;
```

```
with BASKIN_ROBBINS; use BASKIN_ROBBINS;
procedure GET_ICE_CREAM is
   YOUR_NUMBER : BASKIN_ROBBINS.NUMBERS;
   procedure GO_TO_DAIRY_QUEEN is separate;
begin

   BASKIN_ROBBINS.TAKE( YOUR_NUMBER );
   loop

      if BASKIN_ROBBINS.NOW_SERVING = YOUR_NUMBER then
         BASKIN_ROBBINS.SERVE( YOUR_NUMBER );
         exit;
      else

         GO_TO_DAIRY_QUEEN;
         exit;

      end if;
   end loop;
end GET_ICE_CREAM;
```

Types

Private types

```
package INTEGER_STACK is
    type STACK is limited private;
    procedure POP ( ITEM : out INTEGER;
                       OFF_OF:in out STACK);
    procedure PUSH (ITEM: in INTEGER;
                        ON: in out STACK);
private
    --Define what a stack looks like
end INTEGER_STACK;
```

Types

Private types

```
with INTEGER_STACK;
use INTEGER_STACK;
procedure STACK_THEM is
     MY_STACK,YOUR_STACK:STACK;
     AN_ITEM: INTEGER
 begin
     PUSH (ITEM=>20,ON=>MY_STACK);
     PUSH(ITEM=>30,ON=>YOUR_STACK);
     PUSH(40,ON=>MY_STACK);
     .
     .
     POP(AN_ITEM,OFF_OF=>MY_STACK);
     --AN_ITEM = 40
 end STACK_THEM;
```

Control Statements

SEQUENTIAL

ASSIGNMENT
PROCEDURE CALL
RETURN
NULL
BLOCK

CONDITIONAL

IF
CASE

ITERATIVE

LOOP

TASKING

ENTRY CALL
DELAY
ABORT
ACCEPT
SELECT

OTHERS

GOTO
RAISE
CODE

Control Statements

Sequential

ASSIGNMENT

-- Replaces variable on left with expression on right

```
AN_INTEGER := ( 5*2) + 34;
```

PROCEDURE CALL

-- Executes a procedure

```
POP ( AN_INTEGER, OFF_OF => MY_STACK );
```

NULL

-- Explicitly does nothing

```
null;
```

Control Statements

Sequential

RETURN

-- Causes control to be passed back to the caller of a subprogram

For a procedure...

```
procedure A_PROCEDURE is
   AN_INTEGER : INTEGER;
begin
   AN_INTEGER := 5;
   return;
   null; -- never gets executed
end A_PROCEDURE;
```

Control Statements

Sequential

RETURN

-- For a function, returns a value

```
function IS_GREATER ( FIRST, SECOND : in INTEGER )
                                          return BOOLEAN;
begin
  return ( FIRST > SECOND );
end IS_GREATER;
```

-- Every function must have at least one
   return statement

Control Statements

Sequential

BLOCK

-- Used to localize declarations and/or effects

```
procedure MAIN_PROGRAM is
  VARIABLE : FLOAT;
begin
   -- some statements
   declare
      LOCAL_VARIABLE : FLOAT;
   begin
     LOCAL_VARIABLE := 4.0;
     VARIABLE := 70.0;
   end;
   VARIABLE := 10.0;
end MAIN_PROGRAM;
```

Control Statements

Conditional

IF

```
if MY_VALUE = 27 then
  HIS_VALUE := 21;
  THEIR_VALUE := 22;
end if;

if MACHINE_IS_RUNNING then
  SET_NEW_SPEED ( 47 );
else
  COUNT_TIME_DOWN ( CURRENT_TIME );
end if;
```

Control Statements

Conditional

IF

```
if MACHINE_IS_RUNNING then
  SET_NEW_SPEED ( 47 );
elsif MACHINE_IS_IDLE then
  START_MACHINE_UP;
else
  COUNT_TIME_DOWN ( CURRENT_TIME );
end if;
```

Control Statements

Conditional

```
   type DAY_TIMES is ( EARLY_AM,MID_AM,LUNCH,AFTERNOON,
                       LATE_AFTERNOON,DINNER,EVENING,NIGHT );
   TIME : DAY_TIMES := AFTERNOON;
begin
  if TIME = EARLY_AM then
    DRINK_COFFEE;
  elsif TIME = MID_AM then
    DRINK_COFFEE;
  elsif TIME = LUNCH then
    GO_EAT;
  elsif TIME = AFTERNOON then
    STAY_AWAKE;
  elsif TIME = LATE_AFTERNOON then
    GET_READY_TO_GO_HOME;
  else
    GET_READY_FOR_TOMMORROW;
  end if;

end;
```

Control Statements

Conditional

CASE

```
case TIME is
   when EARLY_AM | MID_AM => DRINK_COFFEE;
   when LUNCH => GO_EAT;
   when AFTERNOON => STAY_AWAKE;
   when LATE_AFTERNOON => GET_READY_TO_GO_HOME;
   when others => GET_READY_FOR_TOMMORROW;
 end case;
```

Control Statements

Iterative

BASIC LOOP

```
loop
  -- statements
end loop;
```

EXIT STATEMENT

```
loop
   if X = 20 then
      exit;
   end if;
end loop;
```

```
loop
  loop
    if X = 20 then
       exit;
    end if;
  end loop;
end loop;
```

Control Statements

Iterative

```
 OUTER:
 loop

   INNER:
   loop
     if X = 20 then
        exit OUTER;
     end if;
     exit INNER when X = 21;
     X := X + 2;
   end loop INNER;
end loop OUTER;
```

Control Statements

Iterative

FOR LOOP ITERATION SCHEME

```
with TEXT_IO; use TEXT_IO;
procedure PRINT_ALL_VALUES is
   type COLORS is ( RED, WHITE, BLUE );
   package COLOR_IO is new ENUMERATION_IO ( COLORS );
   use COLOR_IO;

begin

   for INDEX in 1..5 loop
      null;
   end loop;

   for A_COLOR in COLORS loop
     PUT ( A_COLOR );
     NEW_LINE;
   end loop;
end PRINT_ALL_VALUES;
```

Control Statements

Iterative

```
for MY_INDEX in 20..40 loop
   -- some statements
end loop;

for YOUR_INDEX in reverse 20..40 loop
    -- some statements
end loop;
```

Control Statements

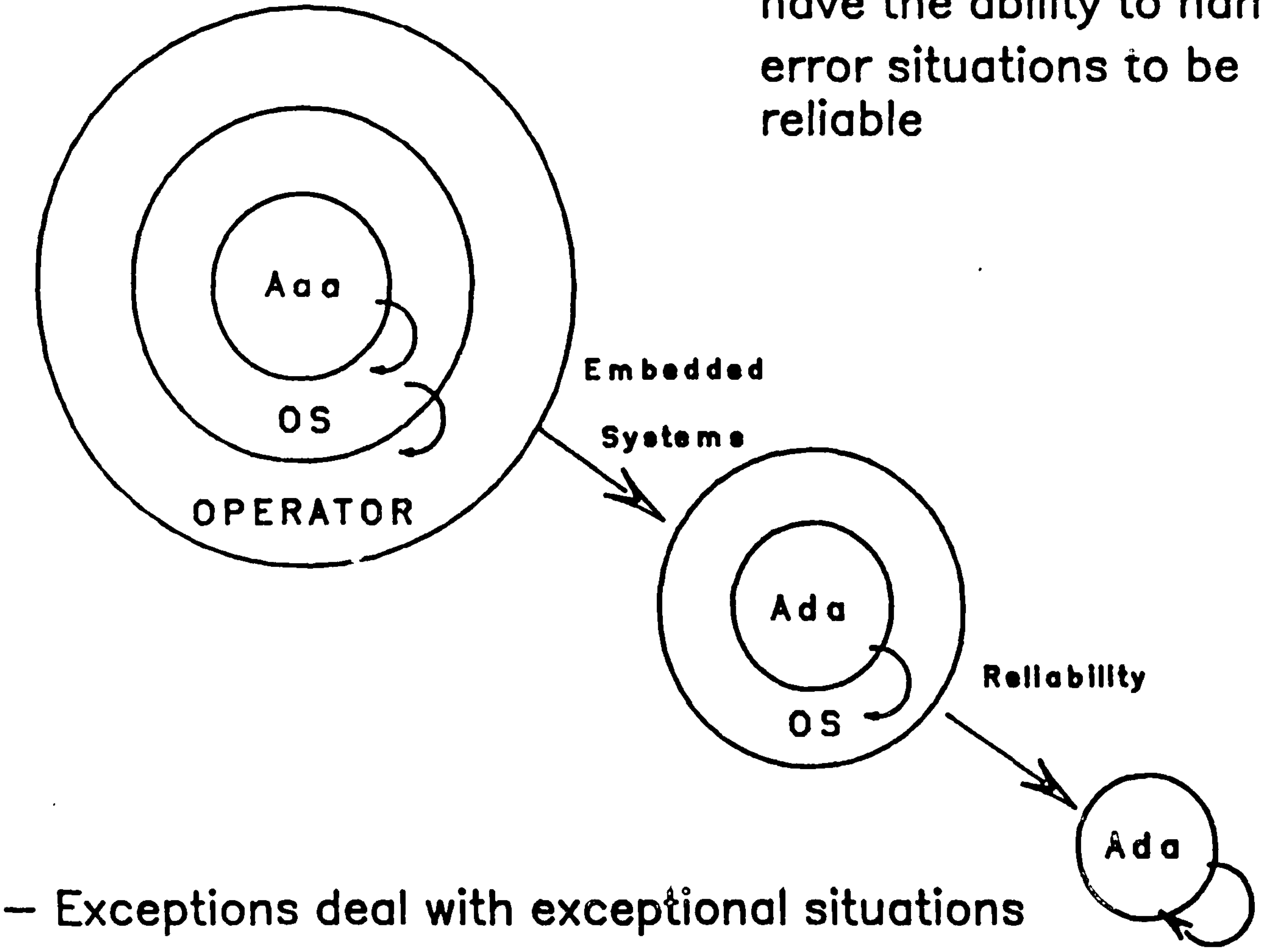
Iterative

WHILE LOOP ITERATON SCHEME

```
while NOT_DARK loop
   PLAY_TENNIS;
end loop;

TURN_ON_LIGHTS;
```

Exceptions

-- Real time systems must have the ability to handle error situations to be reliable



-- Exceptions deal with exceptional situations

Exceptions

```
with TEXT_IO; use TEXT_IO;
procedure GET_NUMBERS is
  type NUMBERS is range 1..100;
  package NUM_IO is new INTEGER_IO ( NUMBERS );
  use NUM_IO;
  A_NUMBER : NUMBERS;
begin
  loop
    GET ( A_NUMBER );
    NEW_LINE;
    PUT("The number is ");
    PUT ( A_NUMBER );
    NEW_LINE;
  end loop;
exception
  when DATA_ERROR => PUT_LINE("That was a bad number");
end GET_NUMBERS;
```

Exceptions

-- When an exception situation occurs, the exception is said to be "raised"

-- What happens then, depends on the presence or absence of an exception handler

```
begin
  loop
    GET ( A_NUMBER );
    NEW_LINE;
    PUT("The number is");
    PUT ( A_NUMBER );
    NEW_LINE;
  end loop;
end GET_NUMBERS;
```

Exceptions

```
begin
  loop
    begin
      GET ( A_NUMBER );
      NEW_LINE;
      PUT ( "The number is ");
      PUT ( A_NUMBER );
      NEW_LINE;
    exception
      when DATA_ERROR => PUT_LINE("Bad number, try again");
    end;
  end loop;
end GET_NUMBERS;
```

Exceptions

USER DEFINED

STACK_OVERFLOW : exception;
BAD_INPUT : exception;
DEAD_SENSOR : exception;

PREDEFINED

CONSTRAINT_ERROR
NUMERIC_ERROR
PROGRAM_ERROR
STORAGE_ERROR
TASKING_ERROR

I/O EXCEPTIONS

STATUS_ERROR
MODE_ERROR
NAME_ERROR
USE_ERROR
DEVICE_ERROR
END_ERROR
DATA_ERROR

```
package SIMPLE_STACK is

    type STACK_TYPE is limited private;
    subtype ELEMENT_TYPE is CHARACTER;

    procedure PUSH ( A_VALUE : in ELEMENT_TYPE;
                     A_STACK : in out STACK_TYPE );

    procedure POP ( A_VALUE : out ELEMENT_TYPE;
                    A_STACK : in out STACK_TYPE );

    STACK_OVERFLOW, STACK_UNDERFLOW : exception;

private

    type STACK_ITEM;
    type STACK_TYPE is access STACK_ITEM;
    type STACK_ITEM is record
        VALUE : ELEMENT_TYPE;
        NEXT : STACK_TYPE;
    end record;

end SIMPLE_STACK;
```

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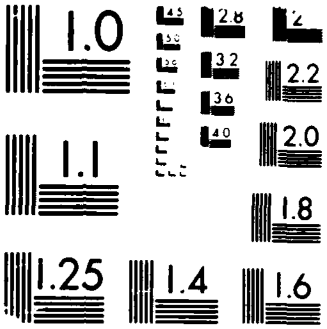


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

```
separate ( SIMPLE_STACK )
procedure POP ( A_VALUE : out ELEMENT_TYPE;
                A_STACK : in out STACK_TYPE ) is

begin

   A_VALUE := A_STACK.VALUE;
   A_STACK := A_STACK.NEXT;

exception

   when CONSTRAINT_ERROR =>
        raise STACK_UNDERFLOW;

end POP;
```

```
separate ( SIMPLE_STACK )
procedure PUSH ( A_VALUE : in ELEMENT_TYPE;
                 A_STACK : in out STACK_TYPE ) is

    TEMP_ITEM : STACK_TYPE;

begin

    TEMP_ITEM := new STACK_TYPE;
    TEMP_ITEM.NEXT := A_STACK;
    TEMP_ITEM.VALUE := A_VALUE;
    A_STACK := TEMP_ITEM;

exception

    when STORAGE_ERROR =>
        raise STACK_OVERFLOW;

end PUSH;
```

```
with TEXT_IO, SIMPLE_STACK;
procedure STACK_USER is

     package COUNT_IO is new TEXT_IO.INTEGER_IO(LONG_INTEGER);

     MY_STACK : SIMPLE_STACK.STACK_TYPE;
     COUNTER : LONG_INTEGER := 0;

begin

     loop

          SIMPLE_STACK.PUSH( 'a', MY_STACK );
          COUNTER := COUNTER + 1;

     end loop;

exception

     when SIMPLE_STACK.STACK_OVERFLOW =>
          TEXT_IO.PUT( "Pushed ");
          COUNT_IO.PUT ( COUNTER );
          TEXT_IO.PUT_LINE( "  times");

end STACK_USER;
```

Generics

Parameterized Program Unit

- subprograms
- packages

Cannot be called

Must be instantiated

Generics

Data Objects

To define the template: use type declaration

To define an instance: use object declaration

Generic program units

To define the template: use generic declaration

To define an instance: use generic instantiation

Generics

Generics Provide:

factorization
reduction in size of program text
more compact code
no unnecessary duplication of source
maintainability
readability
efficiency

Generics

```
procedure INTEGER_SWAP (FIRST_INTEGER, SECOND_INTEGER:
                          in out INTEGER) is

          TEMP : INTEGER;

begin

          TEMP           := FIRST_INTEGER;
          FIRST_INTEGER  := SECOND_INTEGER;
          SECOND_INTEGER := TEMP;

end INTEGER_SWAP;
```

Generics

```
generic

      type ELEMENT is private;
procedure SWAP (ITEM_1,ITEM_2:in out ELEMENT);


procedure SWAP(ITEM_1,ITEM_2:in out ELEMENT) is

     TEMP:ELEMENT;
begin
     TEMP := ITEM_1;
     ITEM_1  := ITEM_2;
     ITEM_2 := TEMP;
 end SWAP;
```

Generics

```
with SWAP;
procedure EXAMPLE is
 procedure INTEGER_SWAP is new SWAP(INTEGER);
 procedure CHARACTER_SWAP is new SWAP(CHARACTER);
 NUM_1, NUM_2 : INTEGER;
 CHAR_1, CHAR_2 : CHARACTER;
begin
 NUM_1 := 10;
 NUM_2 := 25;
 INTEGER_SWAP(NUM_1, NUM_2 );
 CHAR_1 := 'A';
 CHAR_2 := 'S';
 CHARACTER_SWAP(CHAR_1, CHAR_2);
end EXAMPLE;
```

Generics

```
generic
  type DISCRETE_TYPE is (<>);
function NEXT(VALUE : in DISCRETE_TYPE)
                  return DISCRETE_TYPE;
function NEXT(VALUE : in DISCRETE_TYPE)
                  return DISCRETE_TYPE is
begin
  if VALUE = DISCRETE_TYPE'LAST then
    return DISCRETE_TYPE'FIRST
  else
    return DISCRETE_TYPE'SUCC(VALUE);
  end if;
end NEXT;
```

Generics

```
with NEXT;
with TEXT_IO; use TEXT_IO;
procedure MAIN_DRIVER is
  type DAYS is (MON, TUE, WED, THUR, FRI, SAT, SUN);
  TODAY, TOMORROW : DAYS;
  package DAYS_IO is new ENUMERATION_IO (DAYS);
  function DAY_AFTER is new NEXT (DAYS);
begin
  PUT ("Enter the day: ");
  DAYS IO.GET (TODAY);
  TOMORROW := DAY_AFTER (TODAY);
  PUT ("Tomorrow is: ");
  DAYS_IO.PUT (TOMORROW);
end MAIN_DRIVER;
```

Generics

```
with NEXT;
with TEXT_IO; use TEXT_IO;
procedure MAIN_DRIVER_2 is
  type HOUR is range 1..12;
  THIS_HOUR, NEXT_HOUR : HOUR;
  package HOUR_IO is new ENUMERATION_IO (HOUR);
  function HOUR_AFTER is new NEXT (HOUR);
begin
  PUT ("The current hour is: ");
  HOUR_IO.GET (THIS_HOUR);
  NEXT_HOUR := HOUR_AFTER(THIS_HOUR);
  PUT ("Next hour is: ");
  HOUR_IO.PUT (NEXT_HOUR);
end MAIN_DRIVER_2;
```

Generics

```
generic
      SIZE: in POSITIVE;
      type ELEMENT is private;

package STACK is

      STACK_UNDER_FLOW,
      STACK_OVER_FLOW : exception;
      procedure PUSH (ITEM:in ELEMENT);
      procedure POP (ITEM:in out ELEMENT);

end STACK;
```

Generics

```
package body STACK is
     SPACE: array (1..SIZE) of ELEMENT;
     TOP:INTEGER range 0..SIZE:= 0;
     procedure PUSH(ITEM:in ELEMENT)is
     begin
          if TOP = SIZE then
                  raise STACK_OVERFLOW;
          end if;
          TOP := TOP +1;
          SPACE(TOP) := ITEM;
    end PUSH;

    procedure POP(ITEM:in out ELEMENT) is
    begin
         if TOP = 0 then
                 raise STACK_UNDERFLOW;
        end if;
        ITEM := SPACE(TOP);
        TOP := TOP -1;
        end POP;
  end STACK;
```

Generics

```
with STACK;
with TEXT_IO; use TEXT_IO;
procedure STACK_OPS is
   package INT_IO is new INTEGER_IO (POSITIVE);
   use INT_IO;
   INT_ELEMENT : POSITIVE;
   STACK_SIZE : POSITIVE := 50;
   package INTEGER_STACK is new STACK
                              (STACK_SIZE, POSITIVE);
   use INTEGER_STACK;
begin
   PUT ("Enter an element to push on the stack: ");
   GET (INT_ELEMENT);
   PUSH (INT_ELEMENT);
   POP (INT_ELEMENT);
   PUT ("The element popped off the stack was: ");
   PUT (INT_ELEMENT);
end STACK_OPS
```

Generics

```
with STACK, TEXT_IO; use TEXT_IO;
procedure STACK_OPS_2 is
   STACK_SIZE : POSITIVE := 50;
   INT_ELEMENT : POSITIVE;
   FLOAT_ELEMENT : FLOAT;
   package INT_IO is new INTEGER_IO (POSITIVE);
   package REAL_IO is new FLOAT_IO (FLOAT);
   package INT_STACK is new STACK (STACK_SIZE, POSITIVE);
   package FLOAT_STACK is new STACK (100, FLOAT);
   use INT_IO, REAL_IO, INT_STACK, FLOAT_STACK;
begin
   PUT ("Enter a positive element to push on the stack: ");
   GET (INT_ELEMENT);
   PUSH (INT_ELEMENT);
   PUT ("Enter a FLOAT element to push on the stack: ");
   GET (FLOAT_ELEMENT);
   PUSH (FLOAT_ELEMENT);
end STACK_OPS_2;
```

Generics

```
generic

    type ELEM is private;
    with function "*" (LEFT, RIGHT : ELEM)
                         return ELEM is < >;

function SQUARING (X : ELEM) return ELEM;
function SQUARING (X : ELEM) return ELEM is

begin

    return X * X;

end SQUARING;
```

Generics

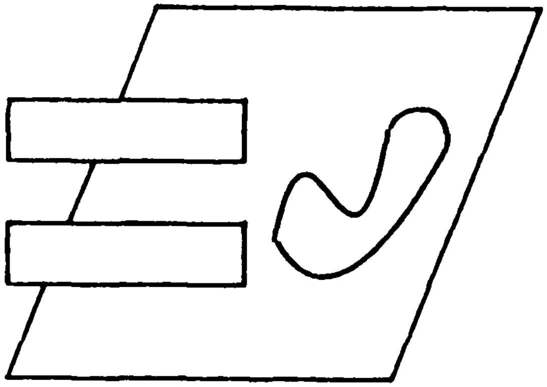
```
with SQUARING;
procedure MATH_PROGRAM is

  function SQUARE is new SQUARING (INTEGER);
  X : INTEGER := 8;

begin

  X := SQUARE (X);

end MATH_PROGRAM;
```

Generics

```
with SQUARING;
procedure MATH_PROGRAM_2 is

  type MATRIX is array (1..3, 1..3) of INTEGER;
  A_MATRIX : MATRIX :=
                (others => (others => 2));
  function MULT (LEFT, RIGHT : MATRIX) return
                        MATRIX is separate;

  function SQUARE_A_MATRIX is new SQUARING
                       (MATRIX, MULT);
begin

  A_MATRIX := SQUARE_A_MATRIX (A_MATRIX);

end MATH_PROGRAM_2;
```

```
generic
   type ELEMENT_TYPE is private;
procedure SWAP ( LEFT, RIGHT : in out ELEMENT_TYPE );

procedure SWAP ( LEFT, RIGHT : in out ELEMENT_TYPE ) is

   TEMP_ELEMENT : ELEMENT_TYPE := LEFT;

begin

   LEFT := RIGHT;
   RIGHT := TEMP_ELEMENT;

end SWAP;
```

Tasks

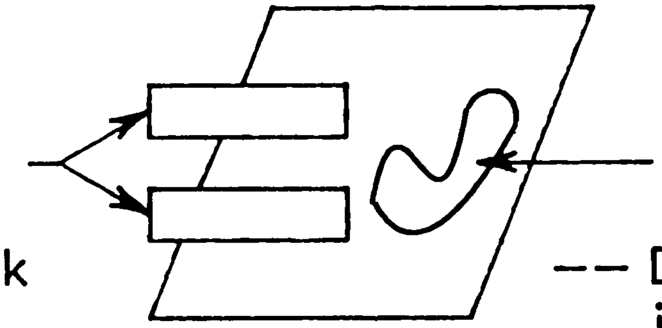


-- A task is an entity that operates in parallel with other entities

-- Tasking may be implemented on

  -- Single Processors
  -- Multi–processors
  -- Multi–computers

Tasks



SPECIFICATION

-- Name of task

-- Communication paths to task (entries)

BODY

-- Details of task implementation

Tasks

```
procedure SENSOR_CONTROLLER is

    function OUT_OF_LIMITS return BOOLEAN;
    procedure SOUND_ALARM;


    task MONITOR_SENSOR; -- specification
    task body MONITOR_SENSOR is  -- body
    begin
          loop
              if OUT_OF_LIMITS then
                 SOUND_ALARM;
              end if;
          end loop;
    end MONITOR_SENSOR;

    function OUT_OF_LIMITS return BOOLEAN is separate;
    procedure SOUND_ALARM is separate;
begin
   null;  -- Task is activated here
end SENSOR_CONTROLLER;
```

Tasks

```
-- a basic task with no communication
 with TEXT_IO; use TEXT_IO;
 procedure COUNT_NUMBERS is
       package INT_IO is new INTEGER_IO (INTEGER);
       use INT_IO;
       task COUNT_SMALL;
       task COUNT_LARGE;

       task body COUNT_SMALL is
       begin
            for INDEX in -100..0 loop
                 PUT(INDEX);
                 NEW_LINE;
             end loop;
        end COUNT_SMALL;

        task body COUNT_LARGE is
        begin
             for INDEX in 0..100 loop
                  PUT(INDEX);
                  NEW_LINE;
               end loop;
          end COUNT_LARGE;

    begin
       null;  --tasks are started here
    end COUNT_NUMBERS;
```

Tasks

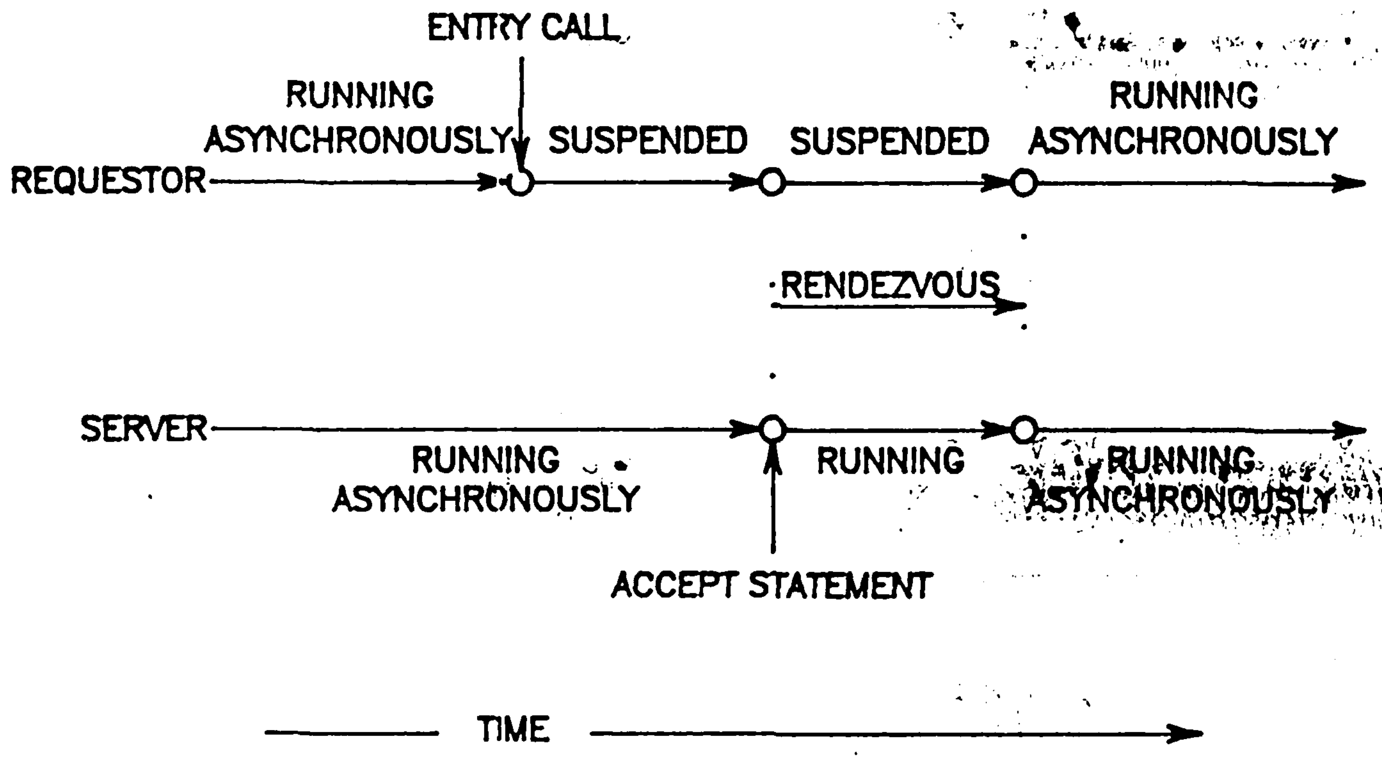
```
--Tasks can communicate with each other
--    via parameters defined in entries

        task CHANNEL is
              entry PRINT(JOB:in JOB_NUMBER);
         end CHANNEL;

--To communicate use an "entry" call

          CHANNEL.PRINT(24);


--When two tasks are synchronized in time
--    and are communicating, we say that the
--    two tasks are in "rendezvous"
```

Tasks

```
--Inside a task, rendezvous occurs when
--    a task's entry has been called and
--    an accept statement is reached

    task body CHANNEL is
          LOCAL_NUMBER : JOB_NUMBER;
     begin
          loop
                accept PRINT(JOB:in JOB_NUMBER)do
                     LOCAL_NUMBER := JOB;
                 end;
                 CALL_PRINTER (LOCAL_NUMBER);
           end loop;
      end CHANNEL;
```

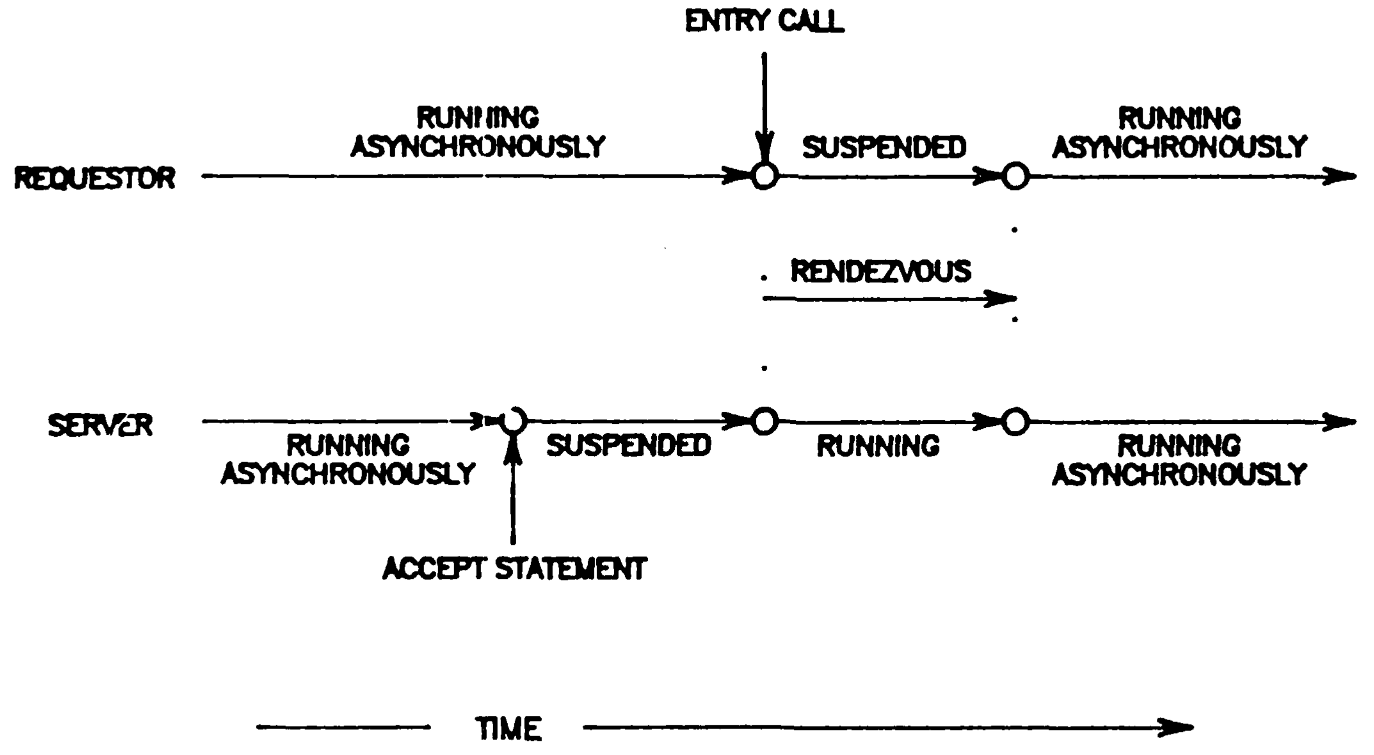
Tasks

STAGES OF A RENDEZVOUS (ENTRY CALL FIRST)



Tasks

STAGES OF A RENDEZVOUS (ACCEPT FIRST)



Tasks

Tasking statements

ENTRY CALL
DELAY
ABORT
ACCEPT
SELECT

Tasks

DELAY

```
--Used to suspend execution for at least
--    the time interval specified

      delay 30.0;
```

ABORT

```
--Used to unconditionally terminate a task
--Only used in extreme circumstances

      abort CHANNEL;
```

Tasks

SELECT

--Used to choose between entries in a task

```
task DRIVE_CONTROL is
     entry READ(DATA: out DATA_TYPE);
     entry WRITE(DATA: in DATA_TYPE);
end DRIVE_CONTROL;

task body DRIVE_CONTROL is
begin
     loop
          select
               accept READ(DATA:out DATA_TYPE)do
               .
               end;
             or
               accept WRITE(DATA:in DATA_TYPE)do
               .
               end;
             end select;
      end loop;
   end DRIVE_CONTROL;
```

```
with LIST_PACKAGE, TEXT_IO;
use  LIST_PACKAGE, TEXT_IO;
procedure ORDER_LIST is

   UNSORTED_FILE : FILE_TYPE;
   SORTED_FILE : FILE_TYPE;

   MAX_ITEMS : constant := 20;

   THE_LIST : A_LIST(1..MAX_ITEMS);
   LIST_INDEX : POSITIVE := 1;

   LAST : NATURAL;
   FILE_NAME : STRING(1..40);
```

```
begin

 PUT_LINE ("This program sorts a list of names, addresses and ");
 PUT_LINE ("phone numbers and puts that sorted list in a file.");
 NEW_LINE (2);
 PUT_LINE ("What is the name of the file to sort?");
 GET_LINE (FILE_NAME, LAST);
 OPEN (UNSORTED_FILE, IN_FILE, FILE_NAME (1..LAST));

 while not END_OF_FILE (UNSORTED_FILE) loop

  GET_LINE (UNSORTED_FILE, THE_LIST (LIST_INDEX).NAME, LAST);
  GET_LINE (UNSORTED_FILE, THE_LIST (LIST_INDEX).ADDRESS, LAST);
  GET_LINE (UNSORTED_FILE, THE_LIST (LIST_INDEX).PHONE_NUMBER, LAST);
  LIST_INDEX := LIST_INDEX + 1;

 end loop;

 SORT (THE_LIST (1..LIST_INDEX - 1));
 CLOSE (UNSORTED_FILE);
```

```
package LIST_PACKAGE is

  MAX_LINE_LENGTH : constant := 80;

  subtype A_LINE is STRING(1..MAX_LINE_LENGTH);

  type ITEMS is record
    NAME : A_LINE := ( others => ' ' );
    ADDRESS : A_LINE := ( others => ' ' );
    PHONE_NUMBER := ( others => ' ' );
  end record;

  type A_LIST is array( POSITIVE range <> ) of ITEMS;

  procedure SORT ( ANY_LIST : in out A_LIST );

end LIST_PACKAGE;
```

```
with SWAP;
package body LIST_PACKAGE is

   procedure SWAP_ITEMS is new SWAP ( ELEMENT_TYPE => ITEMS );

   procedure SORT ( ANY_LIST : in out A_LIST ) is

      -- implements a selection sort

      SMALLEST_INDEX, TEMP_INDEX : POSITIVE;
      SMALLEST_NAME : A_LINE := ( others => ' ' );

   begin
      for SORTED_INDEX in ANY_LIST'RANGE loop
        SMALLEST_INDEX := SORTED_INDEX;
        for CHECK_INDEX in (SORTED_INDEX+1)..ANY_LIST'LAST loop
           if ANY_LIST ( CHECK_INDEX).NAME <
                       ANY_LIST (SMALLEST_INDEX).NAME then
              SMALLEST_INDEX := CHECK_INDEX;
              SWAP_ITEMS ( ANY_LIST(SMALLEST_INDEX),
                           ANY_LIST(SORTED_INDEX) );
           end if;
        end loop;
      end loop;
   end SORT;

end LIST PACKAGE;
```

```
  PUT_LINE("What is the name of the file to output to?");
  GET_LINE( FILE_NAME, LAST );

  CREATE ( SORTED_FILE, OUT_FILE, FILE_NAME(1..LAST) );

  for FILE_ITEM in 1 .. LIST_INDEX – 1 loop

    PUT_LINE( SORTED_FILE,THE_LIST(FILE_ITEM).NAME );
    PUT LINE(SORTED FILE,THE LIST(FILE ITEM).ADDRESS );
    PUT_LINE(SORTED_FILE,THE_LIST(FILE_ITEM).PHONE_NUMBER);
    NEW_LINE(SORTED_FILE);

  end loop;

  CLOSE ( SORTED_FILE );

end ORDER_LIST;
```